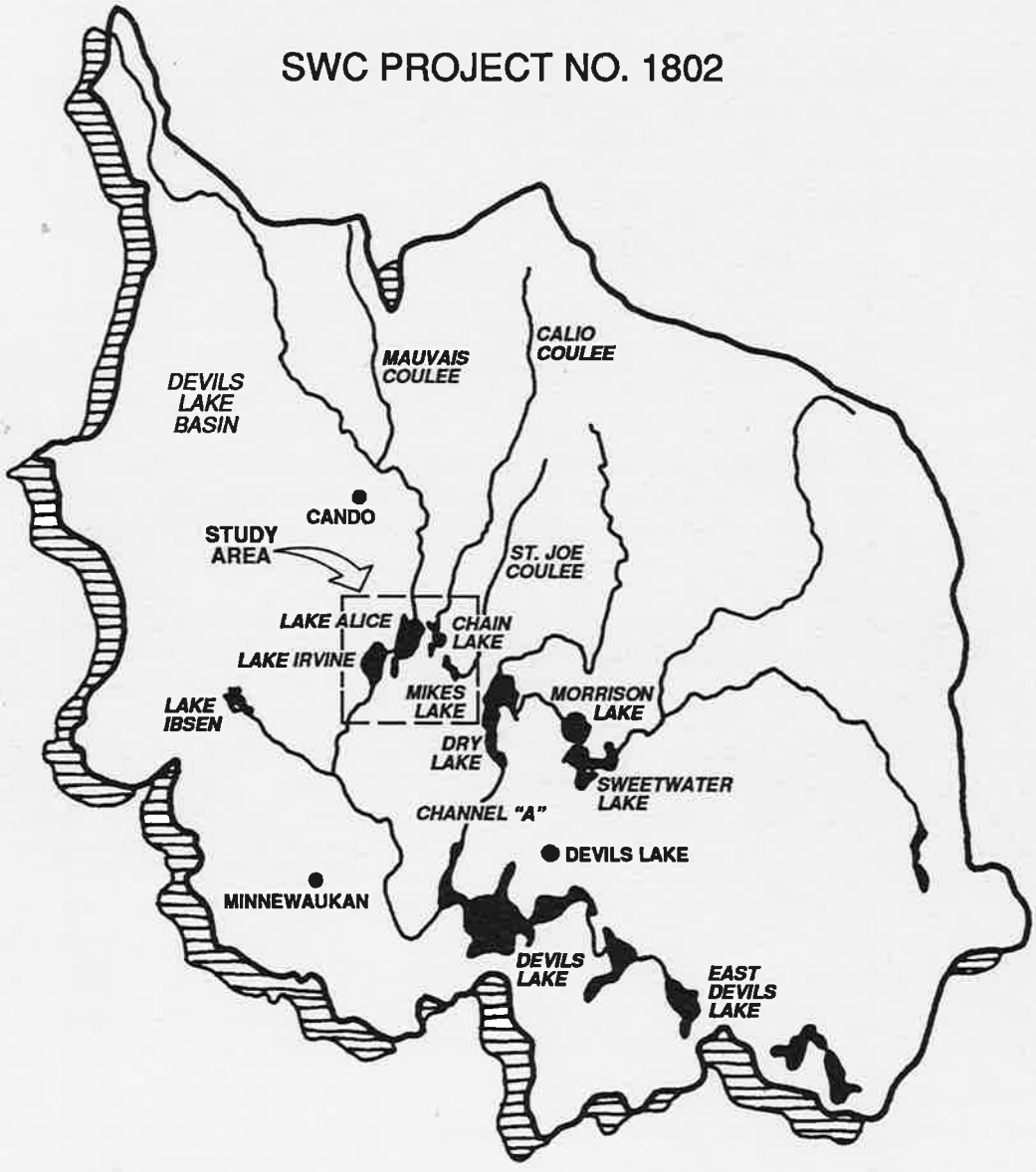
PRELIMINARY ENGINEERING REPORT

Chain Lakes Improvement

SWC PROJECT NO. 1802



NORTH DAKOTA STATE WATER COMMISSION
SEPTEMBER 1991

PRELIMINARY ENGINEERING REPORT

Chain Lakes Improvement
SWC Project #1802

September 1991

North Dakota State Water Commission
900 East Boulevard
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I. INTRODUCTION

Study Objectives:

In January of 1987, the North Dakota State Water Commission entered into an agreement with the Devils Lake Joint Water Resource Board to investigate the feasibility of certain hydraulic improvements to the watercourses in the vicinity of Mikes Lake, Chain Lake, Lake Alice, and Lake Irvine to reduce flood damages. A copy of the agreement is included in Appendix A. Figure 1 shows the location of the study area within the state.

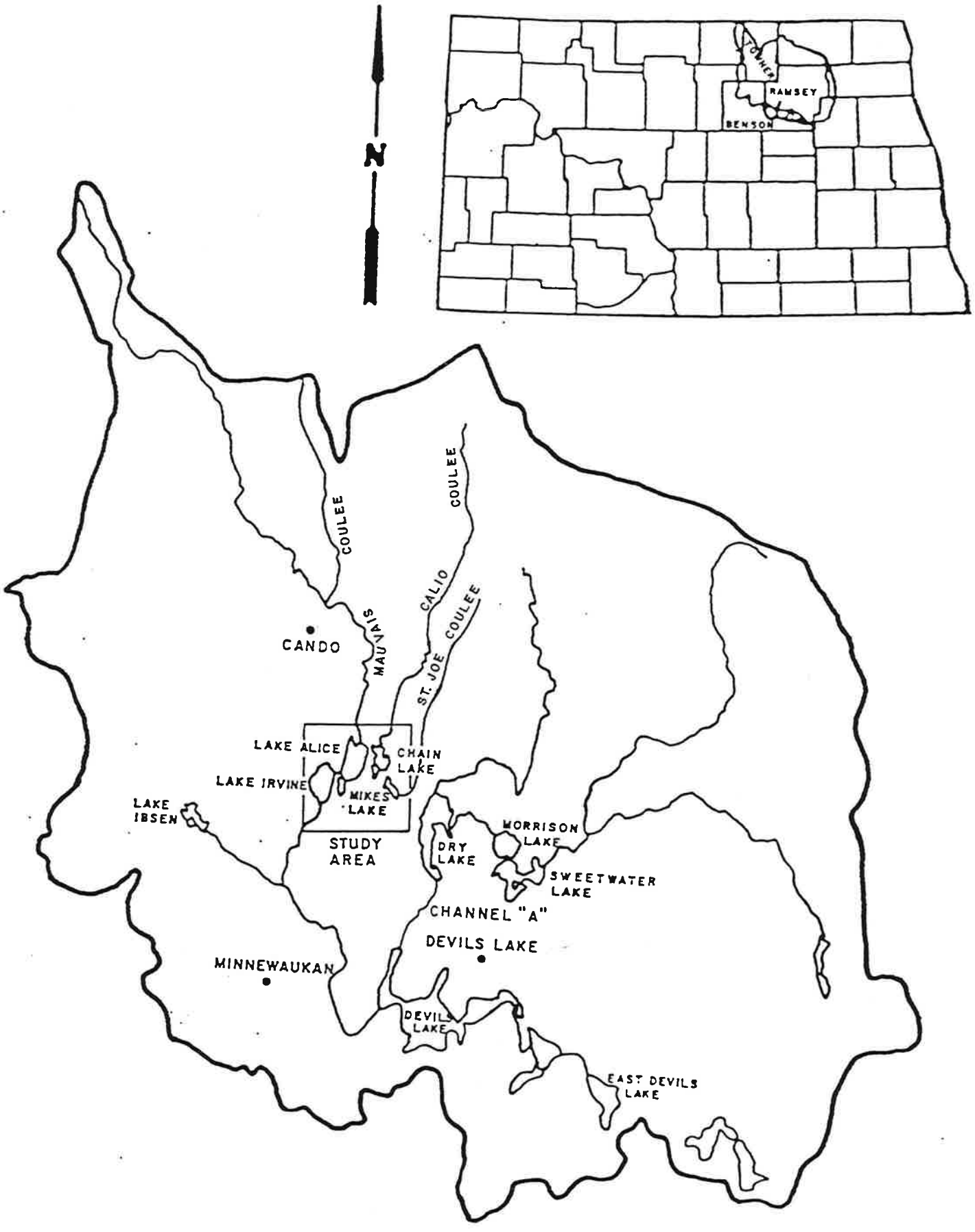
This report contains a description of the hydrologic and hydraulic analysis of the drainage basin, a summary of the preliminary design of the improvements, cost estimates based on the preliminary designs, and a statement of conclusions and recommendations regarding the improvements.

Description of the Study Area:

The study area is located approximately 10 miles west and 15 miles north of the city of Devils Lake in Ramsey County. The area consists of Mikes Lake, Chain Lake, Lake Alice, and Lake Irvine along with the channels, structures, and sloughs that connect the lakes, see Figure 1. These lakes, along with Sweetwater Lake, Morrison Lake, and Dry Lake, are commonly referred to as the Chain Lakes. Prior to 1979, all these lakes were interconnected and the upstream lakes, Sweetwater, Morrison, and Dry Lakes, drained through the study area. In 1979, Channel

FIGURE 1

LOCATION OF STUDY AREA



A was operated for the first time and, since that time, the three upstream lakes have drained directly into Devils Lake, bypassing the study area. The construction of Channel A left the study area with three main tributaries: St. Joe, Calio, and Mauvais Coulees. Lake Irvine discharges into Mauvais Coulee, also referred to as Big Coulee, approximately 1 mile north of Churches Ferry and eventually flows into Devils Lake.

The study area starts on St. Joe Coulee at the section line between Sections 28 and 33, Township 156 North, Range 65 West; and follows St. Joe Coulee downstream to its confluence with Mikes Lake. The study area continues through Mikes Lake, Chain Lake, Lake Alice, and Lake Irvine, including the confluence of Calio Coulee and Mauvais Coulee. The study area follows Mauvais Coulee out of Lake Irvine to Section 35, Township 155 North, Range 67 West.

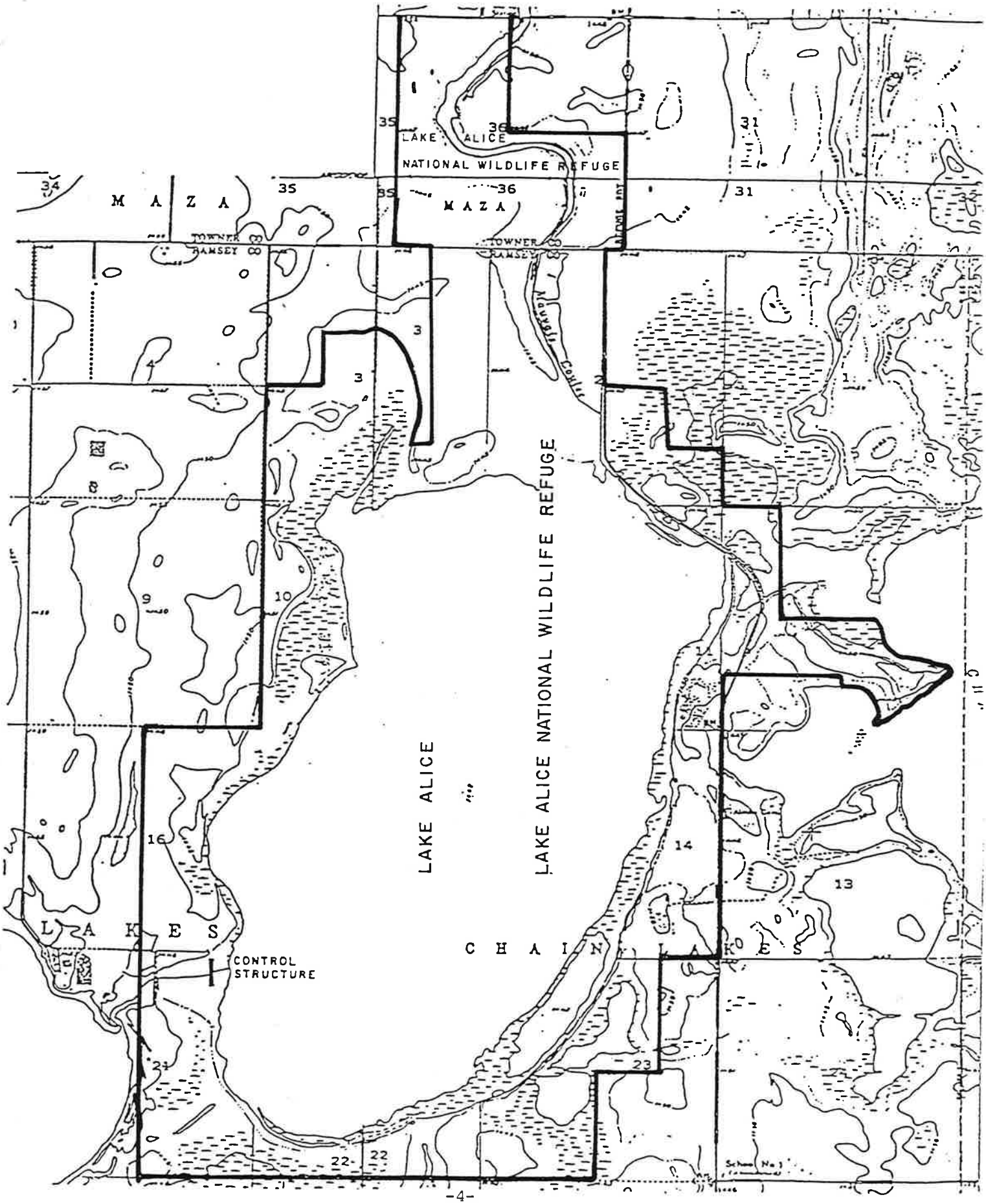
Lake Alice National Wildlife Refuge is located within the study area, see Figure 2. The U.S. Fish and Wildlife Service has a gated structure on the downstream end of Lake Alice to control the water level on the refugee. The structure provides the Service the capability to store water to elevation 1443 msl.

Historical Background:

This study resulted from recommendations made by the Lake Alice Study Group. The Lake Alice Study Group was started as a result of a meeting in July of 1984. The group consisted of

FIGURE 2

LAKE ALICE NATIONAL WILDLIFE REFUGE



representatives from the Ramsey County Water Resource District, the U.S. Fish and Wildlife Service, and the North Dakota State Water Commission. The study group exchanged information and ideas, ground surveys were conducted, and an attempt was made to model the area using the National Weather Service's DWOPER model. The modeling effort was conducted by Dennis Reep, SWC and Joe Lyons, U.S. Fish and Wildlife Service, Denver, Colorado.

The Lake Alice Study Group developed several conclusions. They determined that it would not be possible to provide substantial flood control benefits for events that exceed the 10-year event. However, if the lakes are properly controlled, it should be possible to provide some relief to landowners in the area for more frequent events. The study group recommended five projects that could alleviate flooding of private lands during frequent events. The recommended projects were:

1. Modifications or reconstruction of the control structure at the south end of Lake Irvine;
2. Construction of a channel between Chain Lake and Lake Alice to allow for more efficient flow during spring runoff and after heavy rainstorms;
3. Clean out bottle necks in Mikes Lake and upstream areas to allow for free flow of floodwaters;
4. Improve existing channel and culvert control outlet from the Traynor Lake Area; and
5. Divert high flows from St. Joe Coulee to Calio Coulee.

In January of 1987, the North Dakota State Water Commission entered into an agreement with the Devils Lake Joint Water Resource Board to determine the effectiveness of the improvements

listed above and to investigate other methods of alleviating flooding in the area. Since the agreement was signed, the improvements to the Mikes Lake area have been completed, and were not investigated. Due to opposition by some landowners, the diversion of high flows from St. Joe Coulee to Calio Coulee was not included in this investigation.

Many studies of the Devils Lake basin, including the Chain Lakes area and Mauvais Coulee, have been completed in the past. One of particular interest to this study is the Preliminary Engineering Report, Lower Mauvais Coulee Water Surface Profile Study, December 1980. This study determined the effects of existing channel conditions and road crossings on selected flows. The study also recommended improvements to the channel, culverts, and bridges. Since the study was completed (1980), a few of the recommendations have been implemented, but in at least one instance (river mile 25.9) where an increase in the size of a road crossing was recommended, the size of the structure has been decreased. The old bridge was removed and two 10-foot diameter corrugated metal pipes were installed and the road lowered. Although the existing crossing should not cause flooding in the Chain Lakes, the road will be overtopped during frequent events.

II. HYDROLOGY

The Chain Lakes contribute runoff to Devils Lake. The Devils Lake basin drains approximately 3,320 square miles. About 2,010 square miles of the Devils Lake basin drains into the Chain Lakes system. Approximately 890 square miles of the basin enter Devils Lake through Channel A, and does not affect the study area. The St. Joe Coulee drainage basin comprises 91 square miles which drain into Mikes Lake. The Calio Coulee basin contains 142 square miles, entering Chain Lake. Mauvais Coulee drains approximately 690 square miles at its confluence with Lake Alice. The total area contributing runoff to the study area is approximately 923 square miles. The remaining area, approximately 190 square miles, contributes local runoff to the lakes or enters Mauvais Coulee between Lake Irvine and Little Coulee.

The topography of the basin is generally low hills and flat lands. The lower portion of the basin, and especially the study area, is very flat. The basin contains a large number of shallow depressions and potholes. Many of these depressions are connected by poorly defined channels and swales. The abundance of potholes throughout the basin present difficulties in modeling the hydrology of the area. The runoff from the basin is very dependent on the storage available in the basin which is largely dependent on moisture conditions from the preceding years. Also, the contributing drainage area depends on the storage available

in the basin and precipitation. This makes the determination of runoff for specified return periods difficult.

The inflows for the lakes were determined using the USGS stream gage on Mauvais Coulee near Cando, ND. This gage has a drainage area of 387 square miles. A Log Pearson Type III analysis was done using the gage records to develop 5- and 10-year peak flows and runoff volume at the gage. The Corps of Engineers HEC-1 model was used to develop 5- and 10-year hydrographs for the basin above the gage. The model was calibrated using the gage records. To develop hydrographs for the confluence of Mauvais Coulee and Lake Alice, as well as the mouth of Calio and St. Joe Coulees, the drainage area and time of concentration for each basin was determined. Using these values, the Snyder Unit Graph parameters were determined for each basin and substituted into the HEC-1 model for the basin to develop hydrographs for the coulee. The inflow hydrograph are included in Appendix B. Table 1 contains the peak flows for each coulee for the 5- and 10-year events.

Table 1
Peak Inflow cfs

Coulee	5-year	10-year
St. Joe	912	1920
Calio	1098	2313
Mauvais	1500	3158

III. HYDRAULICS

The National Weather Service (NWS) computer program DWOPER was used to model the Chain Lakes during flood events for both the existing conditions and the proposed changes. This computer program has the capability to model riverine systems with multiple channels as a flood hydrograph travels downstream. The hydrographs developed using HEC-1 were used as inputs for the flood events.

Options:

Thirty options were modeled to determine the effects of the various changes. Initially each modification was modeled and compared to the existing conditions. The later options combine some of the modifications, based on the results of previous options. The following paragraphs summarize the proposed improvements; Figure 3 shows the location of the improvements.

Improve channel capacity and road crossing structures on the lower Mauvais Coulee downstream of Lake Irvine (river mile 18.9 to the west bay of Devils Lake). These improvements were recommended in the Water Commission's 1980 report and were modeled as one improvement in this study. Appendix C contains a summary of the proposed improvements, including the location, priority, and cost of each improvement.

Remove the existing structures at the downstream end of Lake Irvine, between Section 5, Township 155 North, Range 66 West and Section 32, Township 156 North, Range 66 West (river mile 18.9) and replace with a single bridge. The North Dakota Department of Transportation has proposed a bridge, as shown in Figure 4. The State Engineer has determined the normal elevation of Lake Irvine to be 1441.6 feet msl. Therefore, a weir at this elevation is proposed at the bridge.

FIGURE 3

STUDY AREA

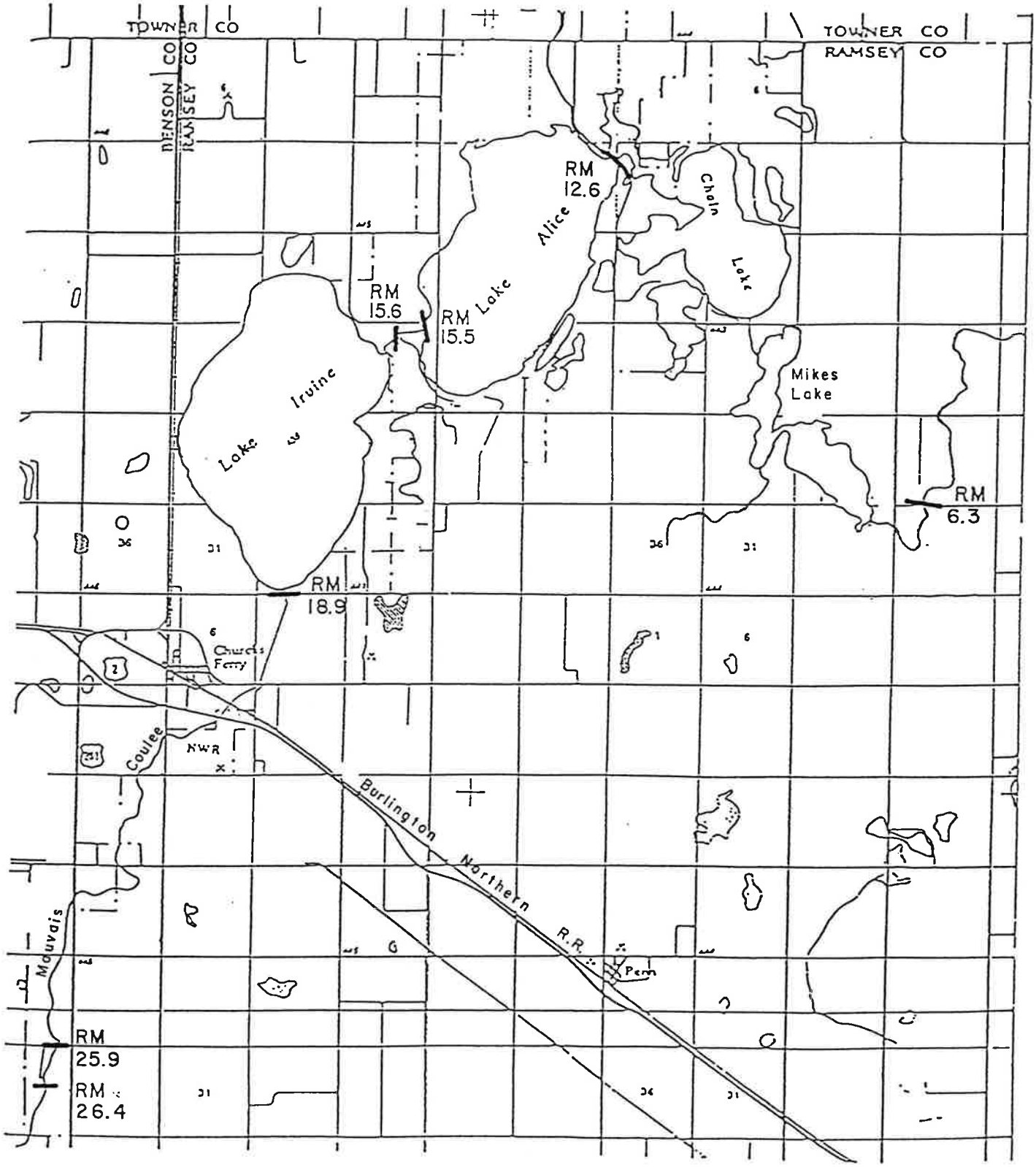
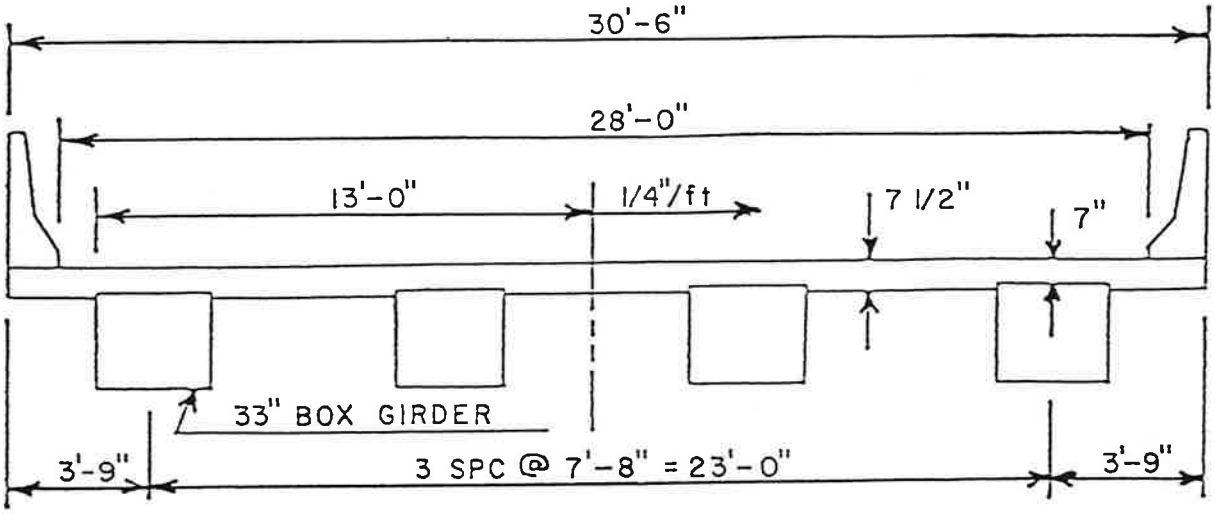


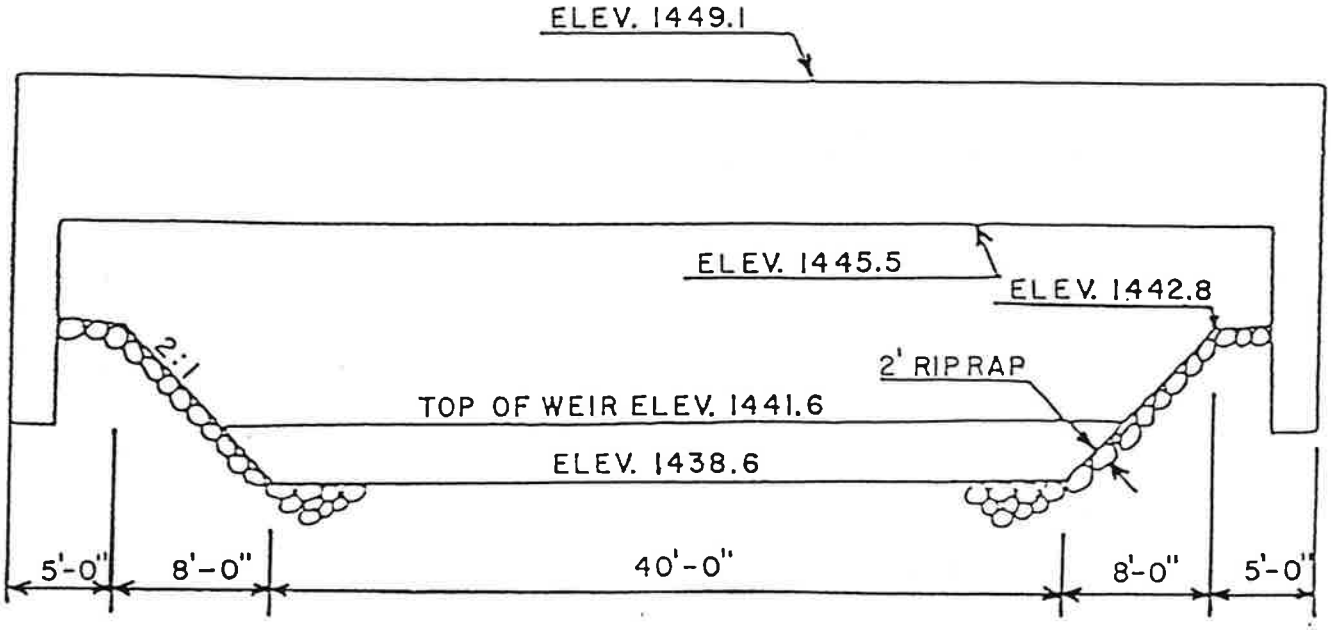
FIGURE 4

PROPOSED BRIDGE AT RIVER MILE 18.9

BRIDGE DETAILS

SINGLE SPAN





Provide fall drawdown capabilities at Lake Irvine, Lake Alice, and Chain Lake to an elevation of 1439 feet msl to provide additional storage for the spring runoff. In order to drawdown the lakes, a new control structure needs to be constructed at river mile 18.9 and the channel needs to be improved between the structure and the lake. In some years the U.S. Fish and Wildlife Service may be unwilling to drawdown Lake Alice, leaving only Lake Irvine to provide flood storage. Lake Irvine provides approximately 60 percent of the storage available in the lakes between the elevations of 1439 msl and 1441.6 msl. Therefore, by drawing down Irvine alone at least half the benefit should be realized.

Remove the bridge between Lake Alice and Lake Irvine in Section 21, Township 156 North, Range 66 West (river mile 15.6).

Construct bypass channels around each side of the Lake Alice control structure at river mile 15.5. The channels would be trapezoidal with a bottom width of 300 feet, 4:1 side slopes, and a control elevation of 1443 feet msl.

Improve the channel in the Duck Road area, river mile 12.6. The improvements would be either removing the cattails from the area or constructing a channel through the area. The channel would have a 50-foot bottom at 1441 feet msl, and 4:1 side slopes.

Although the models are referred to as 5- and 10-year events, the assumptions made during the modeling caused the model to report water surface elevations that possibly are slightly high. However, the same assumptions are used in all the models. Therefore, by changing the model to reflect proposed improvements in the flow regime, the changes in water surface elevations at corresponding points should be accurate. The following paragraphs describe the 30 options modeled:

Option 1 models the existing conditions to provide a basis of comparison for the improvements.

Option 2 models the improvements to the lower Mauvais Coulee.

Option 3 consists of replacing the bridge at river mile 18.9 with the proposed bridge and weir.

Option 4 is the same as Option 3 without the weir.

Option 5 replaces the existing control structure with the bridge and weir and leaves the existing structural plate pipe in place.

Option 6 models a fall drawdown of Lakes Irvine, Alice, and Chain to 1439 feet msl.

Option 7 models the removal of the bridge at river mile 15.6.

Option 8 models the bypass channels around the Lake Alice control structure, river mile 15.5.

Option 9 consists of cleaning out the cattails in the Duck Road area, river mile 12.6.

Option 10 models an improved channel through the Duck Road area.

Option 11 combines the improvements along the lower Mauvais Coulee (Option 2) and the fall drawdown of Lakes Irvine, Alice, and Chain (Option 6).

Option 12 combines the proposed bridge and weir at river mile 18.9 (Option 3) and the fall drawdown (Option 6).

Option 13 combines the fall drawdown (Option 6) and the removal of the bridge at river mile 15.6 (Option 7).

Option 14 combines the fall drawdown (Option 6) and the channels around the Lake Alice control structure (Option 8).

Option 15 combines the fall drawdown (Option 6) and the removal of cattails in the Duck Road area (Option 9).

Option 16 combines the drawdown (Option 6) and the improved channel through the Duck Road area (Option 10).

Option 17 combines the improvements to the lower Mauvais Coulee (Option 2) and the proposed bridge and weir at river mile 18.9 (Option 3).

Option 18 combines the improvements to the lower Mauvais Coulee (Option 2) with a larger bridge than modeled in Option 3. This option was used to test the effects of a larger bridge rather than to determine the size of the bridge. Therefore, the

bottom of the bridge opening was set at 100 feet, instead of 40 feet, and the other dimensions of the bridge remained the same as the bridge shown in Figure 4.

Option 19 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9, (Option 3), and the removal of the bridge at river mile 15.6 (Option 7).

Option 20 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option 3), the removal of the bridge at river mile 15.6 (Option 7), and the bypass channels around the Lake Alice control structure (Option 8).

Option 21 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option 3), the removal of the bridge at river mile 15.6 (Option 7), the bypass channels around the Lake Alice control structure (Option 8), and the removal of cattails in the Duck Road area (Option 9).

Option 22 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option 3), the removal of the bridge at river mile 15.6 (Option 7), the bypass channels around the Lake Alice control structure (Option 8), and the channel through the Duck Road area (Option 10).

Option 23 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge and river mile 18.9 (Option 3), and the drawdown of Lake Irvine, Alice, and Chain, (Option 6).

Option 24 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option 3), the fall drawdown of the lakes (Option 6), and the removal of the bridge at river mile 15.6 (Option 7).

Option 25 combines the drawdown of the lakes (Option 6), the bypass channels around the Lake Alice control structure (Option 8), and the removal of cattails in the Duck Road area (Option 9).

Option 26 combines the drawdown of the lakes (Option 6), the bypass channels around the Lake Alice control structure (Option 8), and the channel through the Duck Road area (Option 10).

Option 27 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option 3), the fall drawdown of the lakes (Option 6), the removal of the bridge at river mile 15.6 (Option 7), the bypass channel around the Lake Alice control structure (Option 8), and the removal of cattails in the Duck Road area (Option 9).

Option 28 combines the improvements to the lower Mauvais Coulee (Option 2), the proposed bridge at river mile 18.9 (Option

3), the fall drawdown of the lakes (Option 6), the removal of the bridge at river mile 15.6 (Option 7), the bypass channels around the Lake Alice control structure (Option 8), and the channel through the Duck Road area (Option 10).

Option 29 combines the improvements to the lower Mauvais Coulee (Option 2), the fall drawdown of the lakes (Option 6), and the channel through the Duck Road area (Option 10).

Option 30 combines the improvements to the lower Mauvais Coulee (Option 2), the fall drawdown (Option 6), and the clean out of cattails in the Duck Road area (Option 9).

IV. RESULTS

Tables 2 and 3 contain the peak water surface elevations at key points through the study area for each option.

Table 2 - Peak Elevations
5-Year Event

Site:	Highway 2	Bridge	Lake Irvine	Lake Alice	Chain Lake	Mikes Lake
RM:	20.49	18.89	17.10	13.90	11.55	8.80
Option:						
1	1444.39	1444.91	1445.02	1445.08	1445.17	1445.40
2	1444.19	1444.85	1444.99	1445.06	1445.17	1445.40
3	1444.37	1444.90	1445.04	1445.10	1445.18	1445.40
4	1444.40	1444.93	1445.02	1445.08	1445.17	1445.40
5	1444.43	1444.95	1445.03	1445.08	1445.17	1445.40
6	1443.97	1444.45	1444.57	1444.62	1444.77	1444.83
7	1444.37	1444.90	1445.03	1445.08	1445.17	1445.40
8	1444.40	1444.92	1445.04	1445.06	1445.16	1445.40
9	1444.35	1444.87	1444.99	1445.04	1445.04	1445.05
10	1444.31	1444.82	1444.94	1444.99	1444.99	1445.00
11	1443.81	1444.40	1444.54	1444.60	1444.77	1444.83
12	1443.96	1444.45	1444.59	1444.64	1444.77	1444.82
13	1443.95	1444.43	1444.56	1444.61	1444.77	1444.83
14	1443.98	1444.46	1444.57	1444.60	1444.76	1444.83
15	1443.92	1444.39	1444.51	1444.56	1444.57	1444.57
16	1443.86	1444.33	1444.45	1444.50	1444.50	1444.51
17	1444.18	1444.85	1445.01	1445.08	1445.18	1445.40
18	1444.23	1444.90	1444.99	1445.06	1445.17	1445.40
19	1444.18	1444.85	1445.01	1445.07	1445.17	1445.40
20	1444.19	1444.86	1445.02	1445.05	1445.16	1445.40
21	1444.14	1444.81	1444.97	1445.00	1445.00	1445.00
22	1444.10	1444.76	1444.93	1444.95	1444.95	1444.95
23	1443.80	1444.40	1444.56	1444.62	1444.77	1444.82
24	1443.80	1444.40	1444.56	1444.62	1444.77	1444.82
25	1443.92	1444.40	1444.52	1444.54	1444.54	1444.55
26	1443.86	1444.32	1444.44	1444.46	1444.47	1444.52
27	1443.75	1444.35	1444.51	1444.53	1444.54	1444.55
28	1443.70	1444.29	1444.45	1444.47	1444.48	1444.52
29	1443.70	1444.28	1444.42	1444.48	1444.48	1444.52
30	1443.76	1444.34	1444.48	1444.54	1444.55	1444.55

Table 3 - Peak Elevations
10-Year Event

Site:	Highway 2 Bridge	Lake Irvine	Lake Alice	Chain Lake	Mikes Lake
RM:	20.49	18.89	17.10	13.90	11.55	8.80
Option:						
Existing 1	1445.68	1446.14	1446.36	1446.45	1446.47	1446.70
2	1445.35	1446.03	1446.32	1446.43	1446.45	1446.70
3	1445.69	1446.25	1446.37	1446.46	1446.47	1446.70
4	1445.73	1446.29	1446.36	1446.45	1446.47	1446.70
5	1445.76	1446.17	1446.35	1446.45	1446.46	1446.70
6	1445.44	1445.93	1446.14	1446.23	1446.24	1446.42
7	1445.63	1446.10	1446.38	1446.46	1446.47	1446.70
8	1445.71	1446.17	1446.40	1446.42	1446.44	1446.69
9	1445.66	1446.12	1446.34	1446.43	1446.44	1446.51
10	1445.64	1446.10	1446.32	1446.41	1446.41	1446.45
11	1445.13	1445.84	1446.09	1446.21	1446.23	1446.42
12	1445.44	1446.03	1446.15	1446.24	1446.25	1446.42
13	1445.39	1445.90	1446.15	1446.23	1446.25	1446.42
14	1445.48	1445.96	1446.17	1446.19	1446.21	1446.42
15	1445.42	1445.91	1446.11	1446.20	1446.21	1446.23
16	1445.38	1445.88	1446.08	1446.17	1446.18	1446.18
17	1445.37	1446.18	1446.32	1446.44	1446.46	1446.70
18	1445.49	1446.19	1446.29	1446.42	1446.44	1446.70
19	1445.37	1446.18	1446.33	1446.44	1446.46	1446.70
20	1445.42	1446.22	1446.37	1446.40	1446.42	1446.69
21	1445.39	1446.20	1446.35	1446.38	1446.38	1446.49
22	1445.37	1446.18	1446.32	1446.35	1446.36	1446.43
23	1445.13	1445.97	1446.10	1446.22	1446.24	1446.42
24	1445.14	1445.97	1446.11	1446.22	1446.24	1446.42
25	1445.45	1445.93	1446.14	1446.17	1446.17	1446.22
26	1445.41	1445.90	1446.11	1446.13	1446.14	1446.14
27	1445.15	1445.98	1446.12	1446.15	1446.15	1446.22
28	1445.11	1445.95	1446.09	1446.12	1446.12	1446.15
29	1445.07	1445.79	1446.04	1446.15	1446.16	1446.16
30	1445.10	1445.82	1446.07	1446.18	1446.19	1446.23

Option 2 reduces the peak elevations downstream of Lake Irvine although it has little effect above Lake Irvine. It was determined that Option 2 alone would not be effective. However, in combination with other options it may be beneficial and was incorporated into later options.

Option 3 causes a negligible effect for the 5-year event and a slightly lower peak immediately upstream of the bridge during a 10-year event. Like Option 2, it may reduce flooding when combined with other options and was incorporated into later options.

Option 4 has essentially no effect, and as Lake Irvine is set at an elevation of 1441.6 feet msl, Option 4 was not investigated further.

Option 5 has a negligible effect for a 5-year event and lowers the peak elevations in Lake Irvine slightly more than Option 3 during a 10-year event. However, the Department of Transportation is reluctant to leave the pipe in place when the bridge is replaced. The same effect could be achieved by enlarging the bridge opening. Therefore, Option 5 was not pursued.

Option 6 results in the greatest reduction of peak elevations for any single improvement. A fall drawdown of Lakes Irvine, Alice and Chain would provide enough storage to reduce the peak elevation of Mikes Lake by approximately 0.6 feet during a 5-year event and almost 0.3 feet during a 10-year event.

Option 7 has essentially no effect. However, it was included in later options.

Option 8 causes the peak elevation of Lake Alice and Chain Lake to be slightly lower. Option 8 was incorporated into later options.

Option 9 causes a significant reduction in the peak elevation of Chain Lake and Mikes Lake in a 5-year event. The reduction during a 10-year event was not as large but still worthwhile.

Option 10 is essentially an improvement of Option 9 and slightly lowers the peak elevations. Both Option 9 and 10 were investigated further.

Option 11 results in improvements over both Option 2 and 6, especially at the downstream end.

Option 12 causes essentially the same peak elevations as the drawdown, Option 6, alone. However, the new bridge is going to be built by the Department of Transportation, and the weir and stop logs are necessary to achieve the drawdown.

Option 13 causes essentially the same results as Option 6, indicating the removal to the bridge at river mile 15.6 would not improve flow through the system.

Option 14 reduces the peak elevations at Lake Alice and Chain Lake during a 10-year event in comparison to the drawdown

alone. During a 5-year event, there was no advantage over the drawdown alone.

Option 15 results in a large reduction in peak elevations over either Option 6 or Option 9, especially in the Mikes Lake area, indicating that both the drawdown and the clean out of cattails in the Duck Road area are worth pursuing.

Option 16 causes improvement over Option 15 at the upstream end. Therefore, the channel through the Duck Road area should be considered.

Option 17 provides approximately the same results as Option 2. However, the new bridge will be built and the downstream improvements will provide benefits to the lower reaches of the study area.

Option 18 has peak elevations similar to Option 17. This indicates that there is no advantage to increasing the size of the proposed bridge at river mile 18.9.

Option 19 has peak elevations similar to Option 17. This indicates that there is no advantage to removing the bridge at river mile 15.6.

Option 20 does reduce the peak elevations of Lake Alice slightly, but not enough to justify the expense of constructing the channels.

Option 21 provides very little improvement over Option 9, indicating that the new bridge at river mile 18.9, the removal of the bridge at river mile 15.6, and the bypass channels around the Lake Alice control structure would provide little benefit.

Option 22 provides very little improvement over Option 10 alone, confirming the results reported for Option 21.

Option 23 lowers the peak elevations, especially at the downstream end during a 10-year event, suggesting that the combination of the drawdown and the improvements to the lower Mauvais Coulee would be beneficial.

Option 24 results in essentially the same peak elevations as Option 23. Therefore, the removal of the bridge at river mile 15.6 is unnecessary.

Option 25 causes very little change in peak elevations when compared to Option 15, indicating the bypass channel around the Lake Alice control structure would not be an effective option.

Option 26 shows the same thing as Option 25. The addition of a bypass channel around the Lake Alice control structure

lowers the peak elevations very little, but not enough to justify the expense to construct the channels.

Option 27 provides some improvement over Option 15 at the downstream end. Therefore, the downstream improvements may be worthwhile.

Option 28 provides some improvement over Option 16 at the downstream end supporting the results of Option 27.

Option 29 provides reductions in peak elevations greater than most options and within .04 feet of any additional improvements. Suggesting that the fall drawdown, the improvements at Duck Road, and improvements to the lower Mauvais Coulee are the only viable options.

Option 30 lowers the peak elevations slightly less than Option 29, supporting the results reported for Option 29. The benefits of the removal of cattails and the construction of a channel through the Duck Road area are very similar.

The fall drawdown of Lake Irvine, Lake Alice, and Chain Lake (Option 6) provide the greatest reduction in peak elevations and should be the first option considered for construction. It is recognized that the Fish and Wildlife Service may not allow Lake Alice to be lowered every year. However, a drawdown of Lake Irving to 1439 msl and Chain Lake to a level equal to Lake Alice,

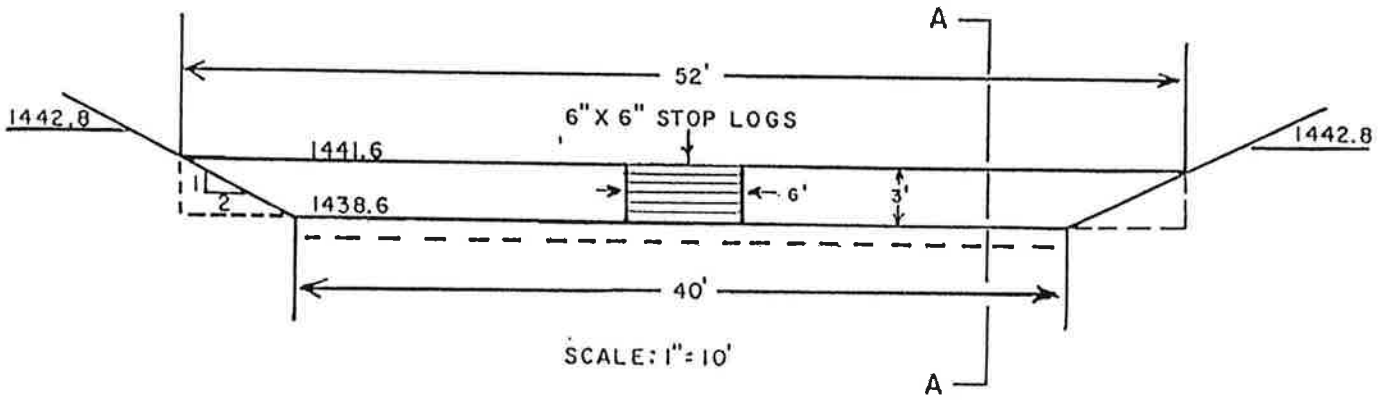
provides substantial benefits. The channel through the Duck Road area (Option 10) or the clean out of cattails in the area (Option 9) is a clear second option to reduce the peak elevations. Stage hydrographs of the lakes are included in Appendix B to illustrate the benefits of these options. The plots show the existing conditions, the effects of the drawdown alone, and the effects of the drawdown combined with the channel through the Duck Road area. The hydrographs were ended after 30 days as the peak elevations had been reached in all cases. The improvements to the lower Mauvais Coulee would not significantly reduce the peak elevations in the lakes, however, the improvements reduce the time required to lower the upper lakes after a flood. The improvements would also reduce the time required to draw the lakes down in the fall. The remaining options lowered the peak elevations less than .04 feet, which is less than 1/2-inch. Therefore, the costs of the remaining options were not calculated as the benefit of these options is essentially nonexistent.

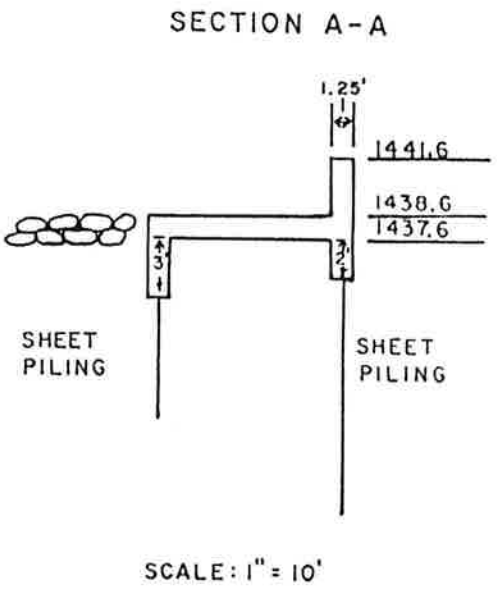
V. PRELIMINARY DESIGN

The preliminary design for the improvements below Lake Irvine was described in the Preliminary Engineering Report, Lower Mauvais Coulee Water Surface Profile Study. No further design work on these improvements was included in this study. The cost of the improvements to the lower Mauvais Coulee were estimated at $1,627,800 in 1980. Based on the Consumer Price Index, the costs would have increased 65 percent, resulting in present cost for these improvements of approximately $2.7 million. However, the 1980 study presents recommendations for which improvements would be the most beneficial. Those recommendations are still valid, and if only the Phase I improvements are constructed, the costs would be lower.

The fall drawdown would require a new control structure at Lake Irvine, as well as some channel work between Lake Irvine and the structure. The Department of Transportation is planning to construct a new bridge at that location, therefore, the only additional cost would be the control structure and channel improvements. The control structure, Figure 5, would consist of a weir at the upstream end of the bridge with a 3-foot by 6-foot stop log bay. The top of the weir would be at 1441.6, the bottom of the bridge at 1438.6. A concrete apron would extend 8 feet downstream of the weir and sheet piling would be driven below the weir a distance of 12 feet. The stop logs would consist of six logs 6 feet long and 6 inches square. The structure would be placed near the roadway to enable equipment to lift the stop logs

FIGURE 5
PROPOSED CONTROL STRUCTURE





from the bridge deck. The stop log structure should enable the lakes to be drawn down from 1441.6 msl to 1439 msl in approximately 100 days. The channel between the structure would also need to be improved. The channel bottom should be lowered to 1438.6 msl, with a bottom width of 50 feet. Approximately 700 cubic yards of earth would need to be excavated to construct the control structure and improve the channel. The cost for the structure, not including the bridge, is shown in Table 4.

Table 4 - Cost Estimate
Lake Irvine Control Structure

Project	Quantity	Unit	Unit Price	Total
Mobilization		LS	$	$ 3,000
Excavation	700	CY	2.10	1,470
Concrete	31	CY	275.00	8,525
Rebar	4,030	Lb	.55	2,210
Sheet Piling	702	LF	30.00	21,060
Riprap	75	CY	25.00	1,875
Stop logs	6	Ea	10.00	60
Subtotal				$38,200
30% Contingencies and Engineering				11,460
Total				$49,700

The clean out of cattails in the Duck Road area would require only the mowing and/or disking of a path approximately 100 feet wide by 3400 feet long. The exact size of the area needing to be cleaned will vary depending on cattail growth, and the clean out may need to be repeated at regular intervals. The cost of the clean out should be minimal and could be performed by the Board, or the Fish and Wildlife Service.

The alternative to an annual clean-out would be to construct a channel through the Duck Road area. This channel would be trapezoidal in shape with 4:1 side slopes, and have a 50-foot bottom width at an elevation of 1439. The channel would be approximately 3400 feet in length. The cost to construct the channel is shown in Table 5.

Table 5 - Cost Estimate
Duck Road Area Channel

Project	Quantity	Unit	Unit Price	Total
Mobilization		LS	$	$ 2,000
Excavation	8,800	CY	2.10	18,500
Subtotal				$20,500
30% Contingencies and Engineering				6,200
Total				$26,700

VI. SUMMARY

Only three of the options investigated reduce flooding in the Chain Lakes. The three options are: 1) The fall drawdown of Lake Irvine, Lake Alice, and Chain Lake to 1439 feet msl (Option 6); 2) Improvements in the Duck Road area (Option 9 or 10); and 3) Improvements to the lower Mauvais Coulee (Option 2).

The fall drawdown of the lakes (Option 6) provided the most reduction in peak elevations of the lakes. To accomplish the drawdown, a new control structure would need to be constructed at river mile 18.9. The North Dakota Department of Transportation is planning to build a new bridge at this location and the control structure could be incorporated into the bridge. The estimated cost of the structure and channel improvement is $49,700.

The improvements in the Duck Road area would also reduce flooding in the upstream end of the study area. Although removal of the cattails (Option 9) would provide almost as much benefit as a channel (Option 10) at minimal cost, the clean out would need to be repeated at frequent intervals. A channel through the area would cost approximately $26,700, but would prevent the growth of cattails for a much longer time period. The channel would also provide additional flood control benefits.

The improvements to the lower reach of Mauvais Coulee (Option 2) would not reduce flooding in the study area above Lake

Irvine for floods less than a 10-year frequency. However, the improvements do reduce the peak elevations in Mauvais Coulee below Lake Irvine. The Lower Mauvais Coulee Water Surface Profile Study should be consulted to determine which improvements to pursue.

The proposed improvements will reduce flooding during 5- or 10-year events. The improvements will have little if any effect on flooding during larger events such as occurred in 1979. During such large floods, there is too much water in the area to move downstream to Devils Lake without causing flooding problems.

VII. PERMIT REQUIREMENTS

A Corps of Engineers' 404 permit will be required before constructing the channel through the duck road area. Chain Lake is a meandered lake, therefore, the State Engineer will require a sovereign lands permit and a drain permit for the channel and the fall drawdown.

The construction of the new control structure at river mile 18.9 and the clean-out of the channel between the structure and Lake Irvine will require a 404 permit, a sovereign lands permit, and a dam permit. The channel improvements recommended for the lower Mauvais Coulee will also require a 404 permit.

VIII. RECOMMENDATIONS

A new control structure at the downstream end of Lake Irvine should be constructed in conjunction with the Department of Transportation bridge. Lakes Irvine, Alice, and Chain should be drawn down to approximately 1439 feet msl each fall. Also a channel should be constructed in the Duck Road area to improve flows out of Chain Lake and Mikes Lake. Both of these recommendations will require the cooperation of the U.S. Fish and Wildlife Service, and an agreement on the operation of the proposed control structure, as well as the existing Lake Alice control structure should be developed before construction begins.

The improvements to the lower Mauvais Coulee should also be considered. These improvements would not only reduce flooding in the lower portion of the study area, but would improve the drawdown of the lakes. At a minimum, the Phase One improvements of the 1980 study should be completed. The decision to proceed with any of these projects is the responsibility of the Devils Lake Joint Water Resource Board.

The proposed improvements will reduce flooding during 5- or 10-year events. The improvements will have little, if any, effect on flooding during larger events such as occurred in 1979. During such large floods, there is too much water in the area to move downstream to Devils Lake without causing flooding problems.

Appendix A - Agreement

ORIGINAL

SWC Project #1802-1
January 13, 1987

AGREEMENT

Investigation of Chain Lakes Improvements

I. PARTIES

This agreement is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vernon Fahy; and the Devils Lake Joint Water Resource Board, hereinafter referred to as the Joint Board, acting through its Chairman, Dick Regan.

II. PROJECT, LOCATION, AND PURPOSE

The project involves a study of certain hydraulic improvements to the watercourses in the vicinity of Mike's Lake, Chain Lake, Lake Alice, and Lake Irvine to reduce flood damages. These proposed improvements are at the following locations: Section 32, Township 156 North, Range 66 West; Sections 11 and 12, Township 156 North, Range 66 West; Sections 19, 20, 29, and 30, Township 156 North, Range 65 West; Section 28, Township 156 North, Range 66 West; and Sections 33, 34, 35, and 36, Township 157 North, Range 65 West, in Ramsey and Towner Counties of North Dakota.

III. PRELIMINARY INVESTIGATION

The parties agree that further information is necessary concerning the proposed project. Therefore, the Commission shall:

1. Conduct a study to determine the effectiveness of the following:

   A. Modification or reconstruction of the control structure at the Lake Irvine Outlet.

   B. Channelization between Chain Lake and Lake Alice in addition to the reconstruction of Duck Road, with a battery of culverts with flap gates on the Lake Alice side.

C. Cleaning out the constriction in Mike's Lake and upstream areas.

D. Improvement of the existing channel and culvert control outlet from Traynor Lake area.

E. A channel from St. Joe Coulee to Calio Coulee to divert high flows.

2. Conduct a topographic survey of the proposed improvement areas.

3. Develop hydrologic information for the improvements.

4. Prepare preliminary designs for the proposed improvements.

5. Prepare preliminary cost estimates of the improvements.

6. Prepare a preliminary engineering report which presents the results of the study.

IV. DEPOSIT AND REFUND

The Joint Board shall deposit a total of $4500 with the Commission to partially defray the cost of the investigation. Upon receipt of a request from the Joint Board to terminate proceeding further with the investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the Joint Board with a statement of all expenses incurred in the investigation and shall refund to the Joint Board any unexpended funds.

V. RIGHTS-OF-ENTRY

The Joint Board agrees to obtain written permission from any affected landowners for field investigations by the Commission which are required for the investigation.

VI. INDEMNIFICATION

The Joint Board hereby accepts responsibility for and holds the Commission free from all claims and damages to all public and private properties, rights,

or persons arising out of this investigation. In the event a suit is initiated or a judgement rendered against the Commission, the Joint Board shall indemnify it for any judgement arrived at or judgement satisfied.

VII. CHANGES TO THE AGREEMENT

Changes to any contractual provisions herein will not be effective or binding unless such changes are made in writing, signed by both parties, and attached hereto.

NORTH DAKOTA STATE WATER COMMISSION
By:

David A. Sprynczynatyk

by VERNON FAHY
State Engineer

DATE:

Jan. 13, 1987

WITNESS:

James T. Fahy

DEVILS LAKE JOINT WATER RESOURCE BOARD
By:

Dick Regan

DICK REGAN
Chairman

DATE:

January 15, 1987

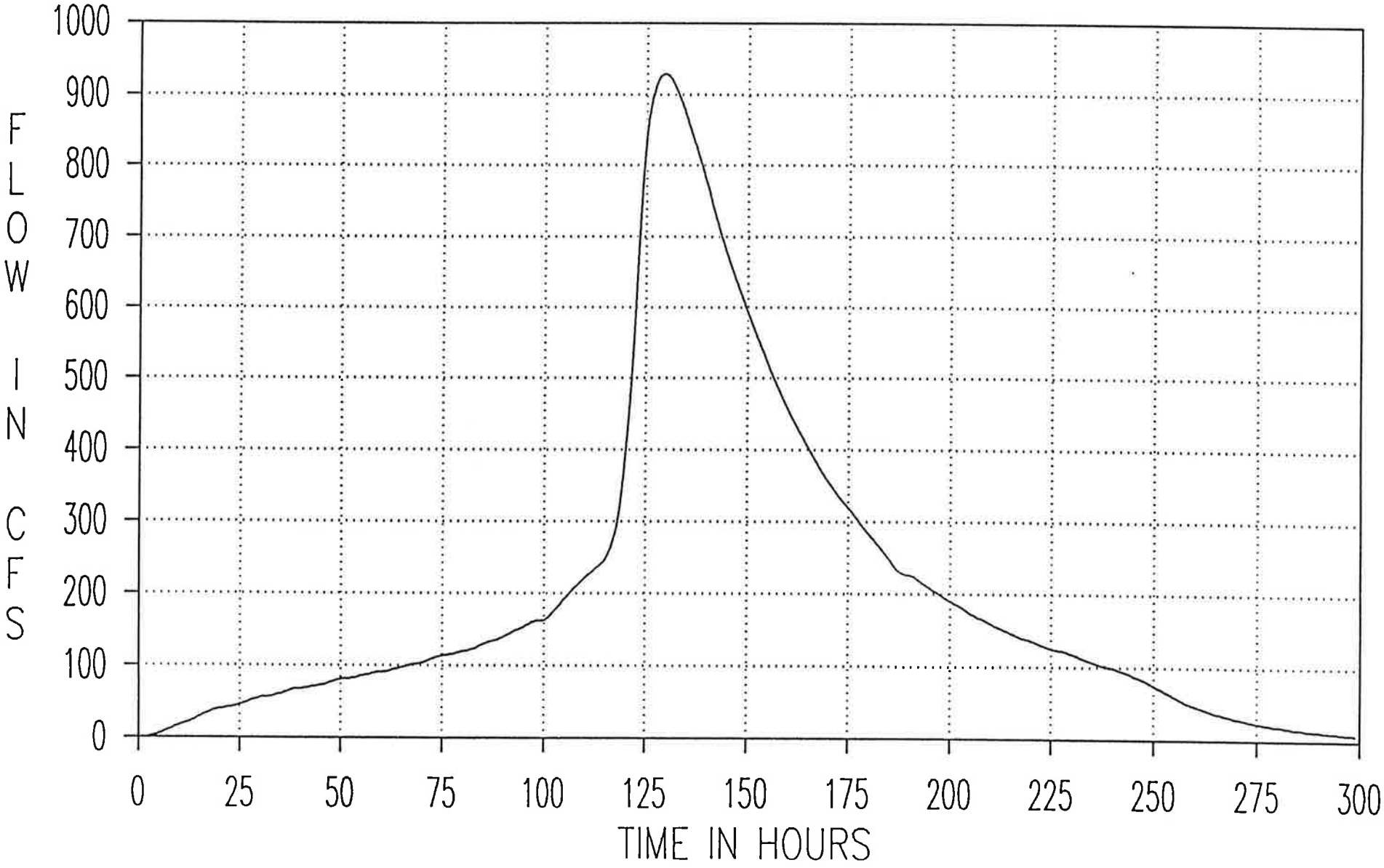
WITNESS:

Herbert Young

Appendix B - Hydrographs

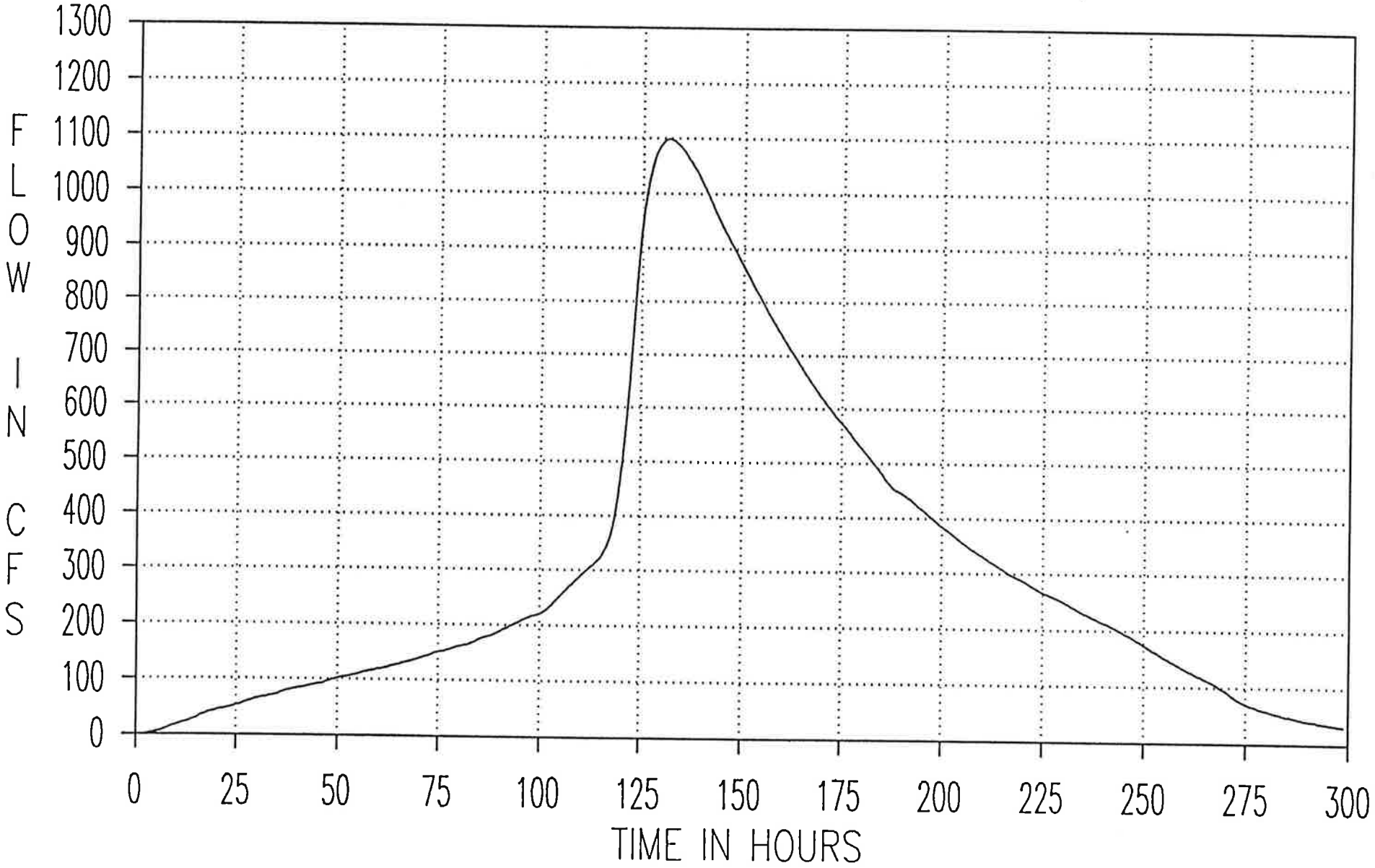
St Joe Coulee Inflow

5-Year Event



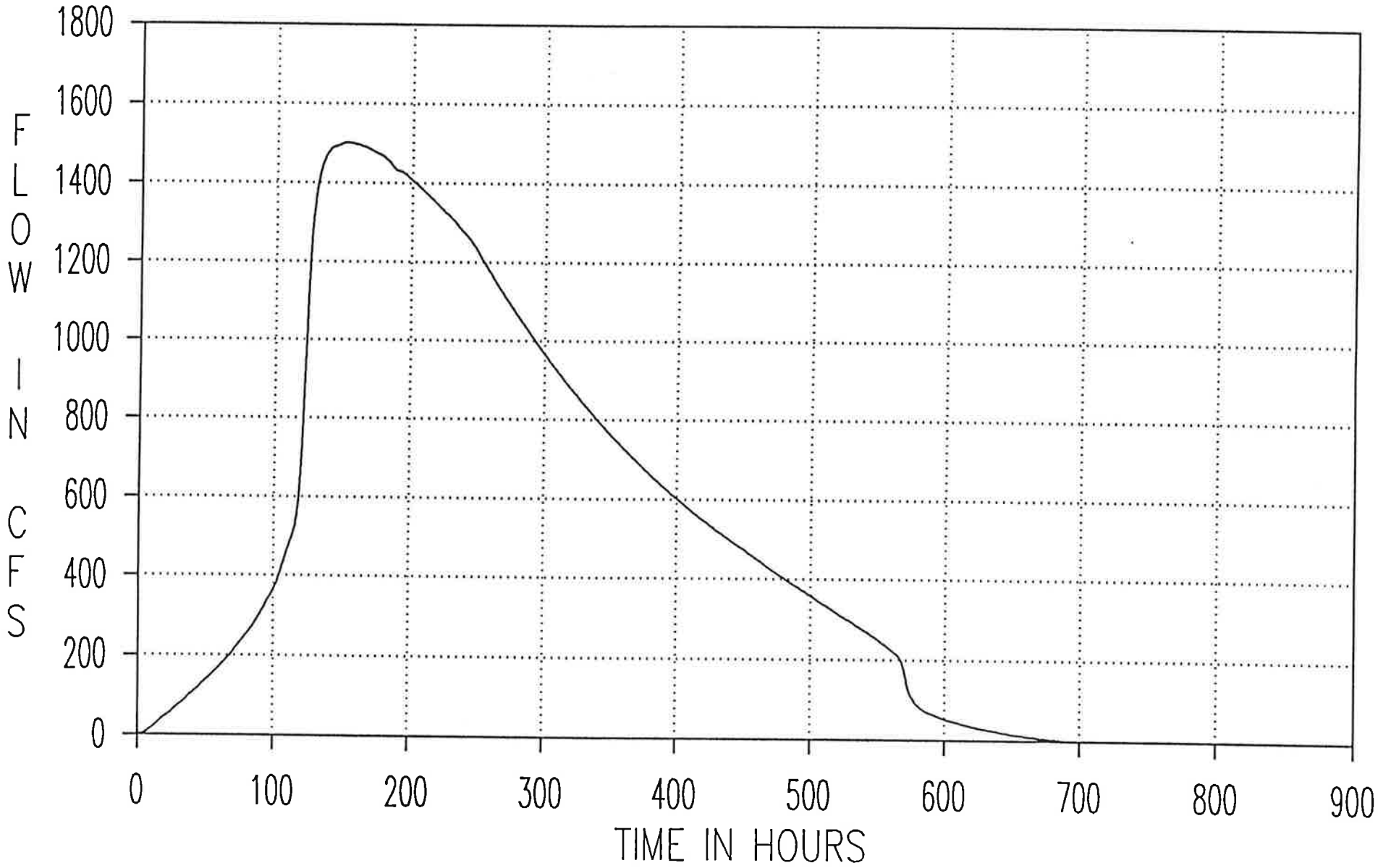
Calio Coulee Inflow

5–Year Return Period



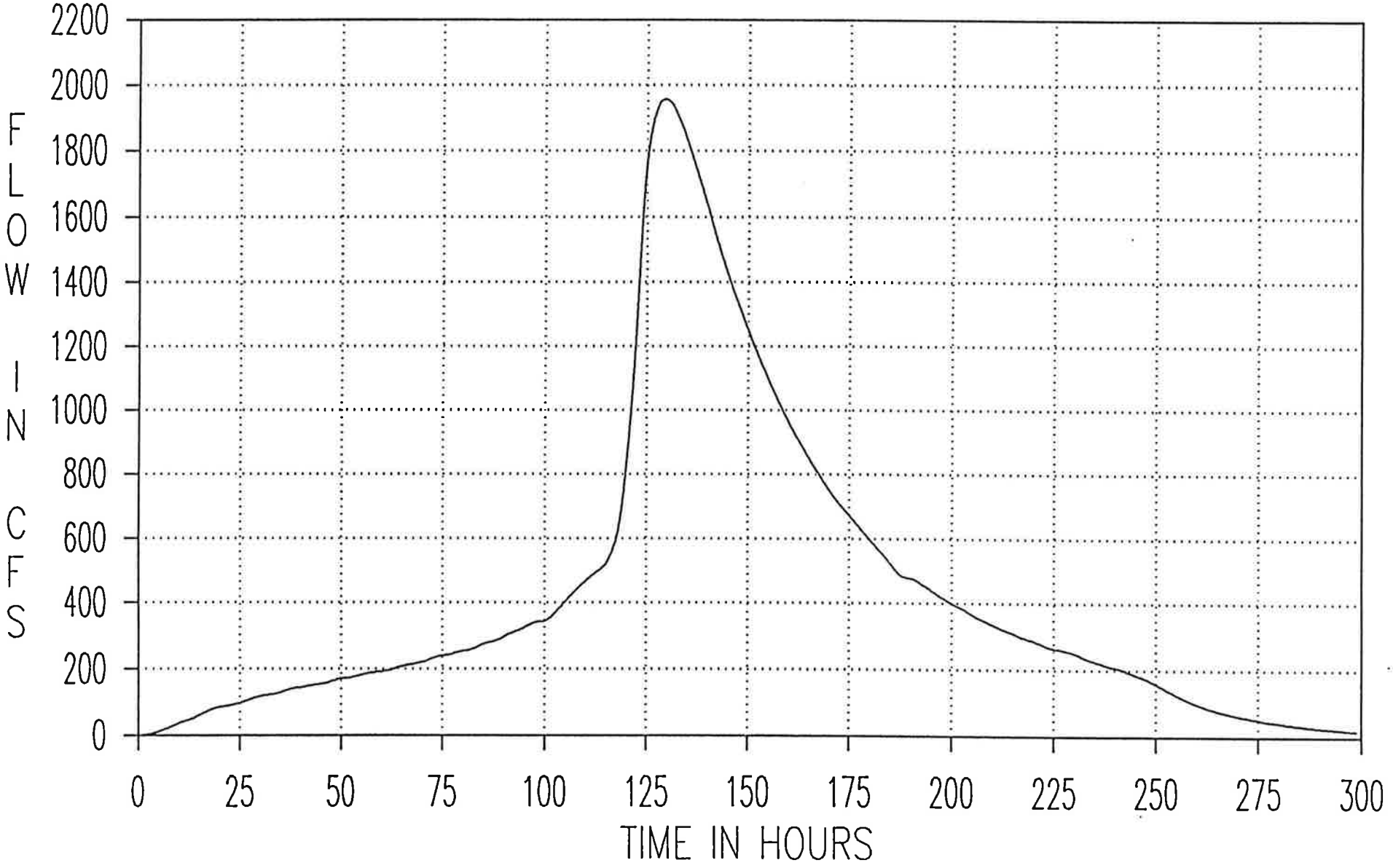
Mauvais Coulee Inflow

5–Year Return Period



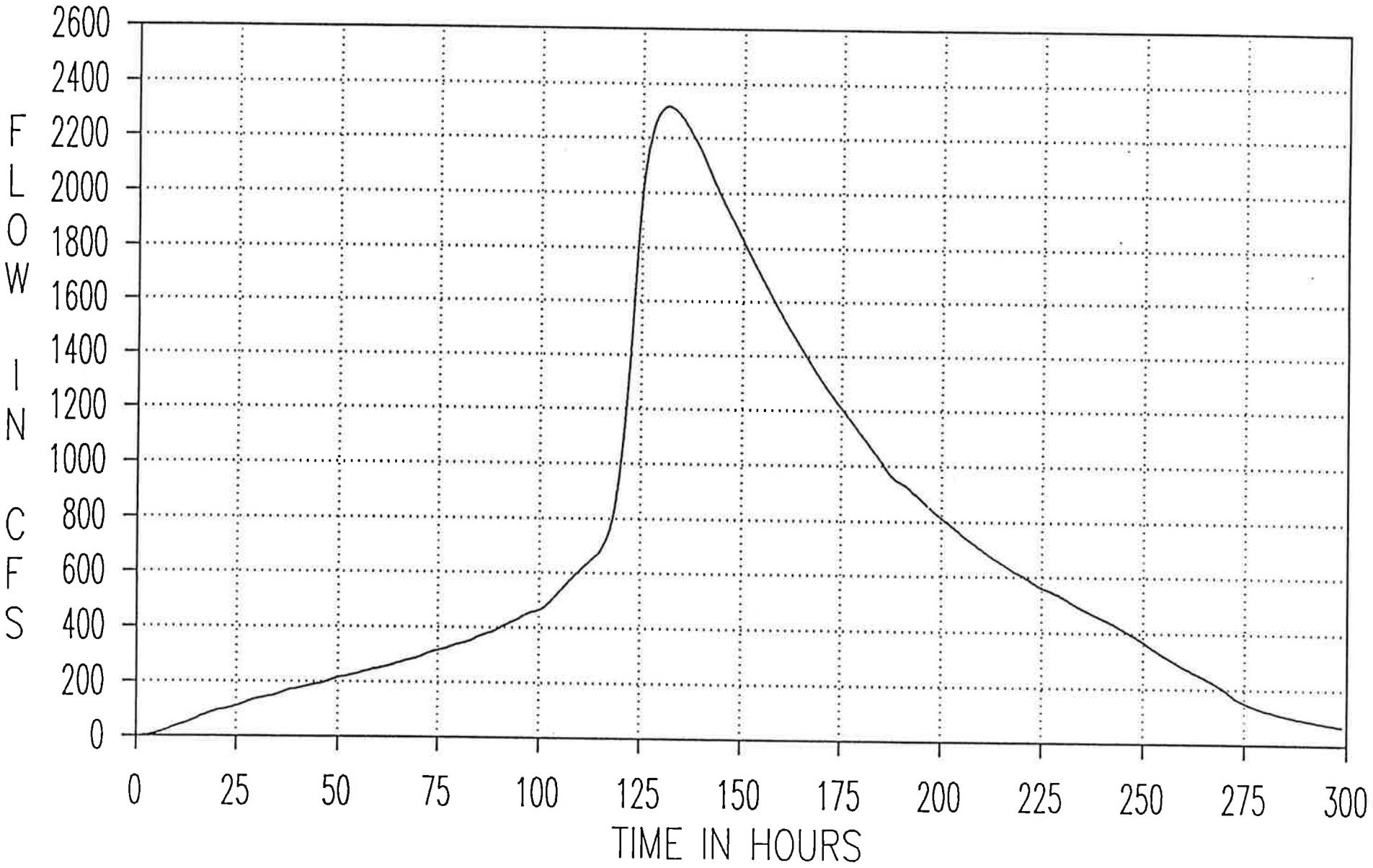
St Joe Coulee Inflow

10–Year Return Period



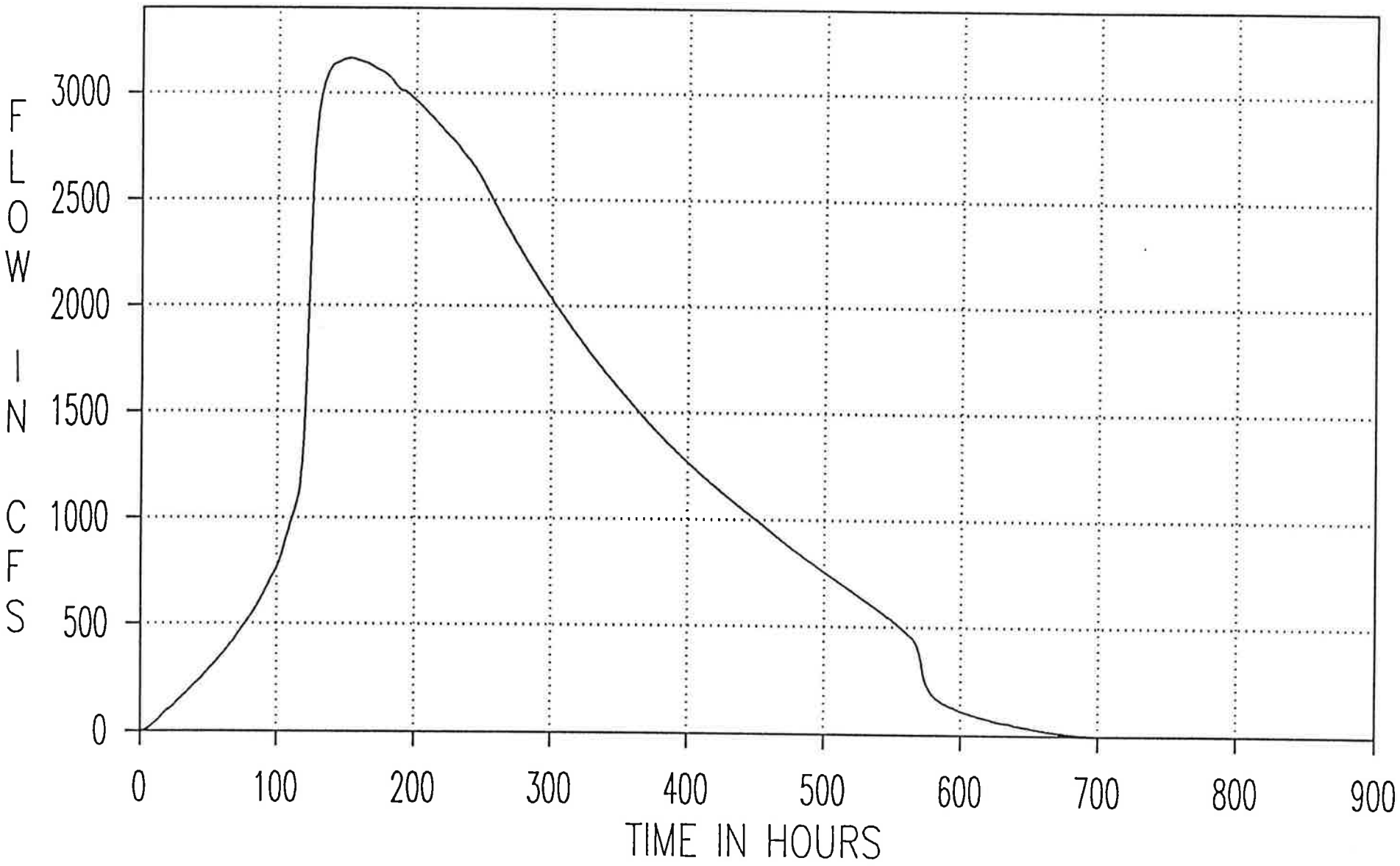
Calio Coulee Inflow

10–Year Return Period



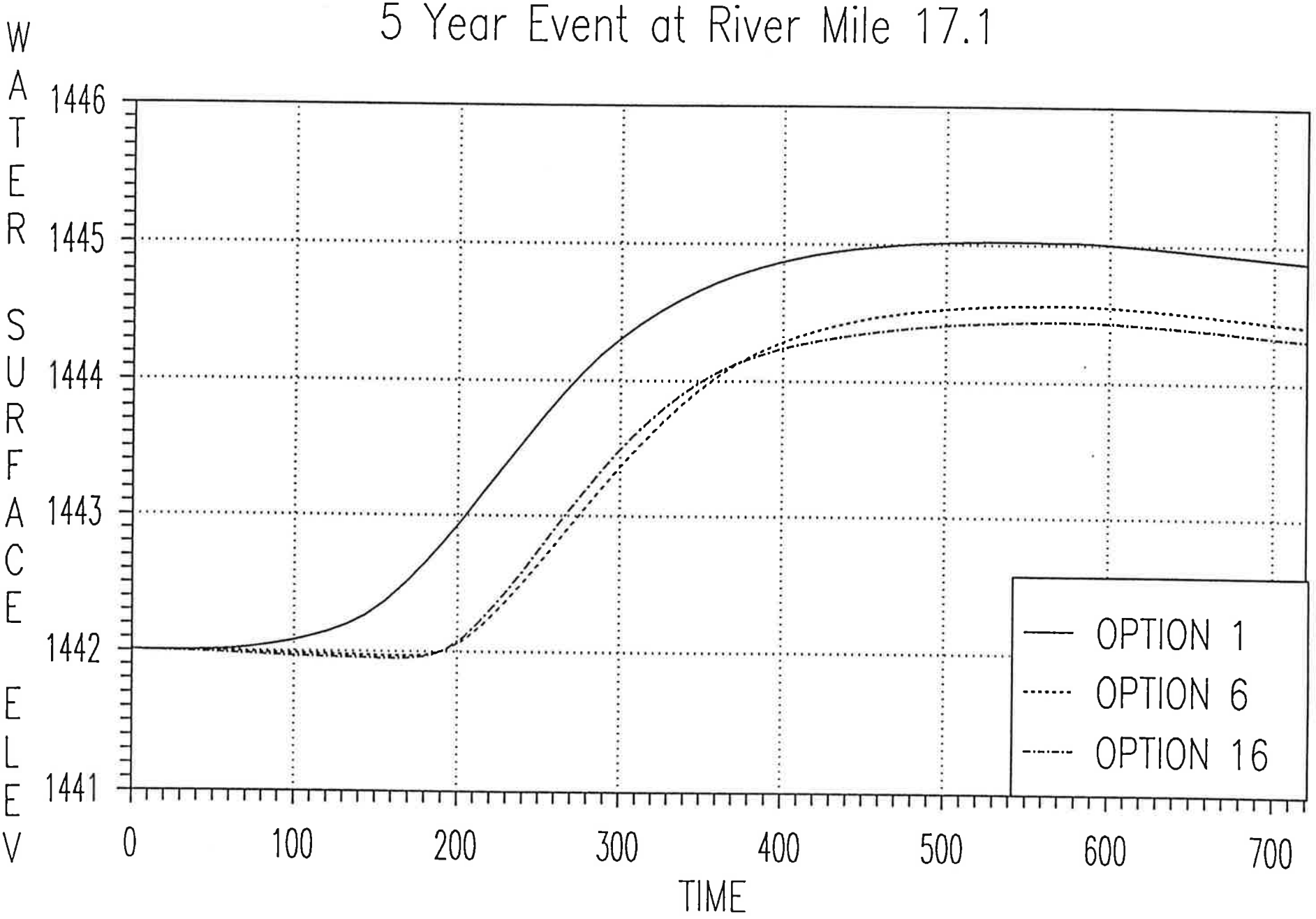
Mauvais Coulee Inflow

10-Year Return Period



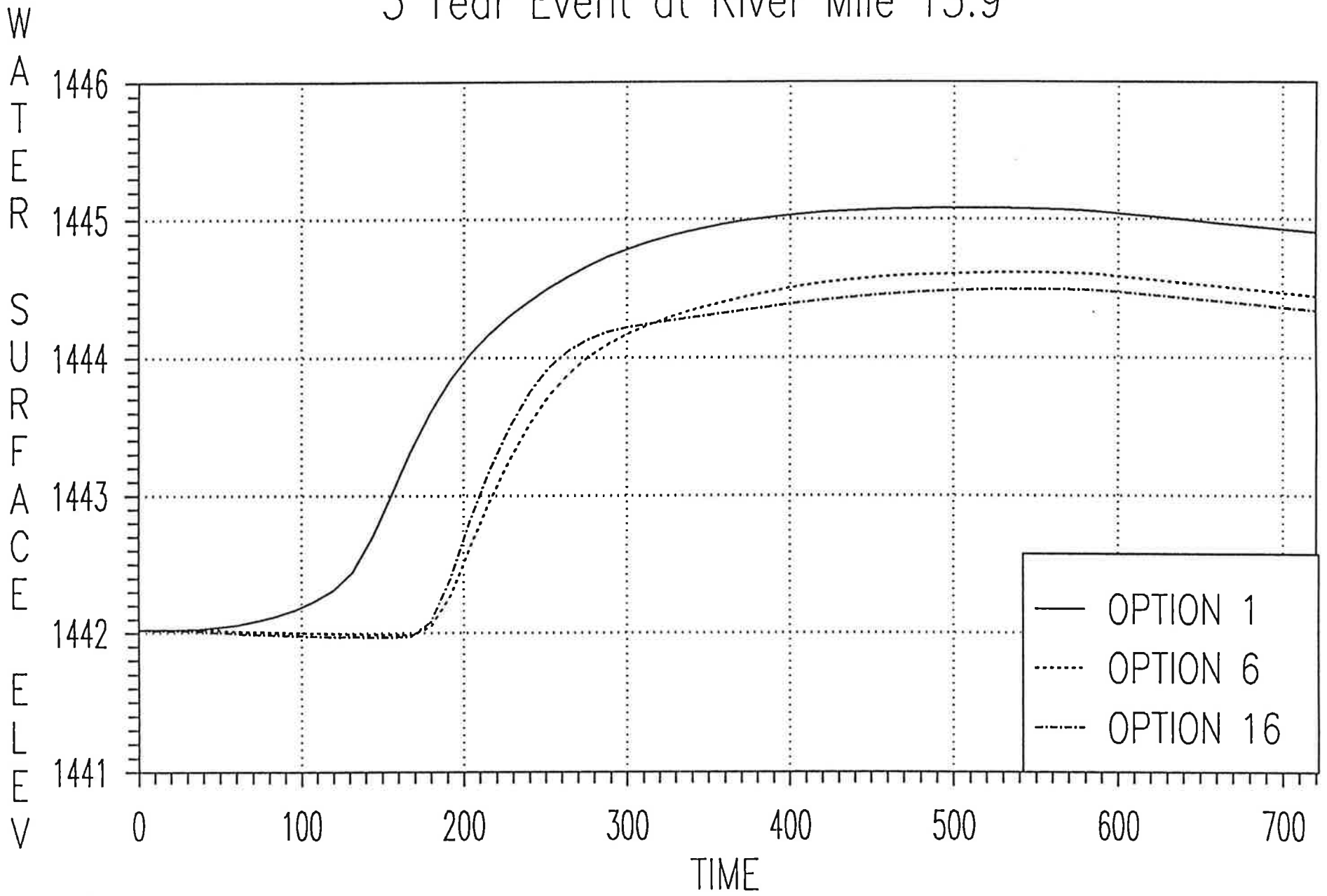
Lake Irvine Stage Hydrograph

5 Year Event at River Mile 17.1



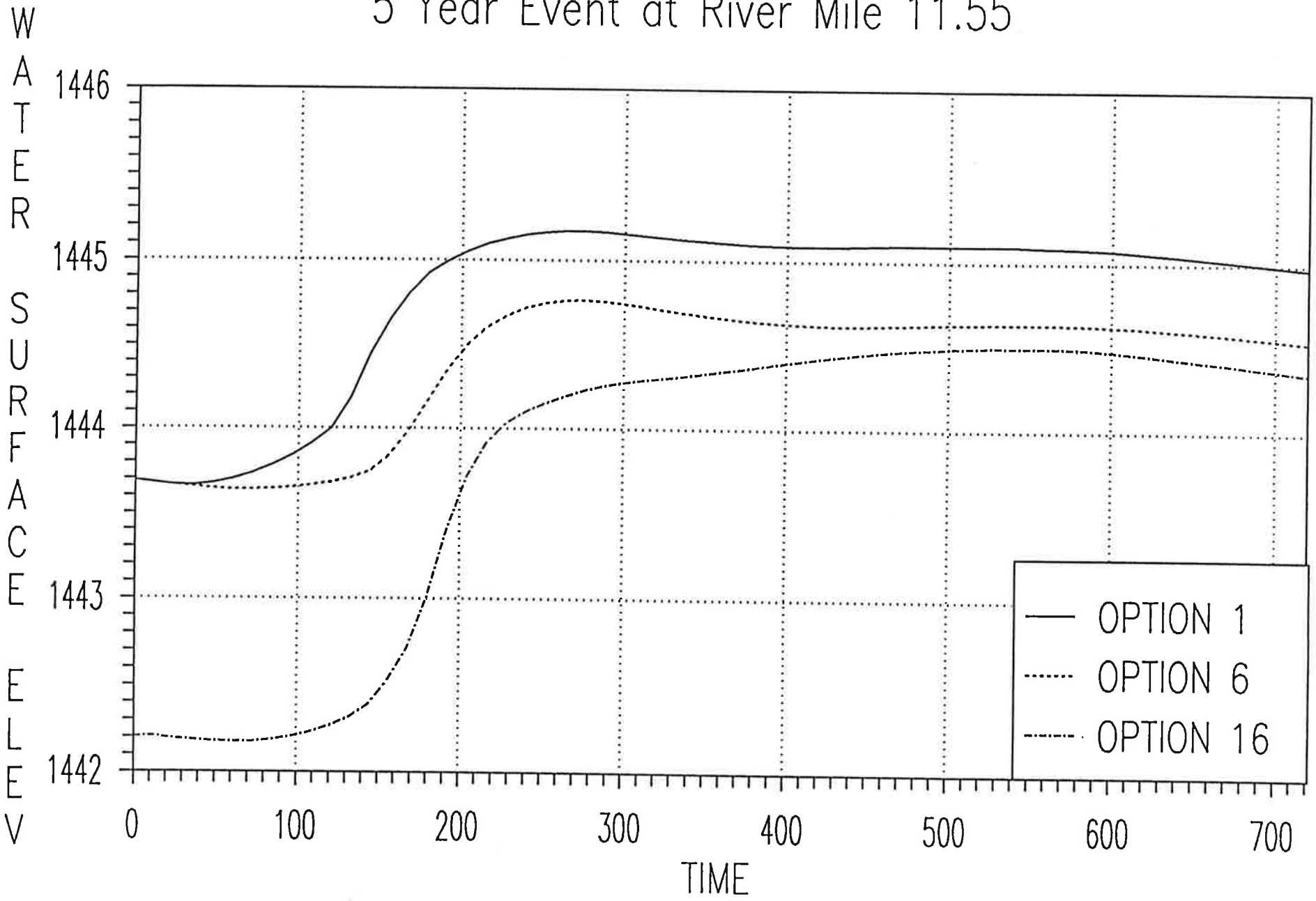
Lake Alice Stage Hydrograph

5 Year Event at River Mile 13.9



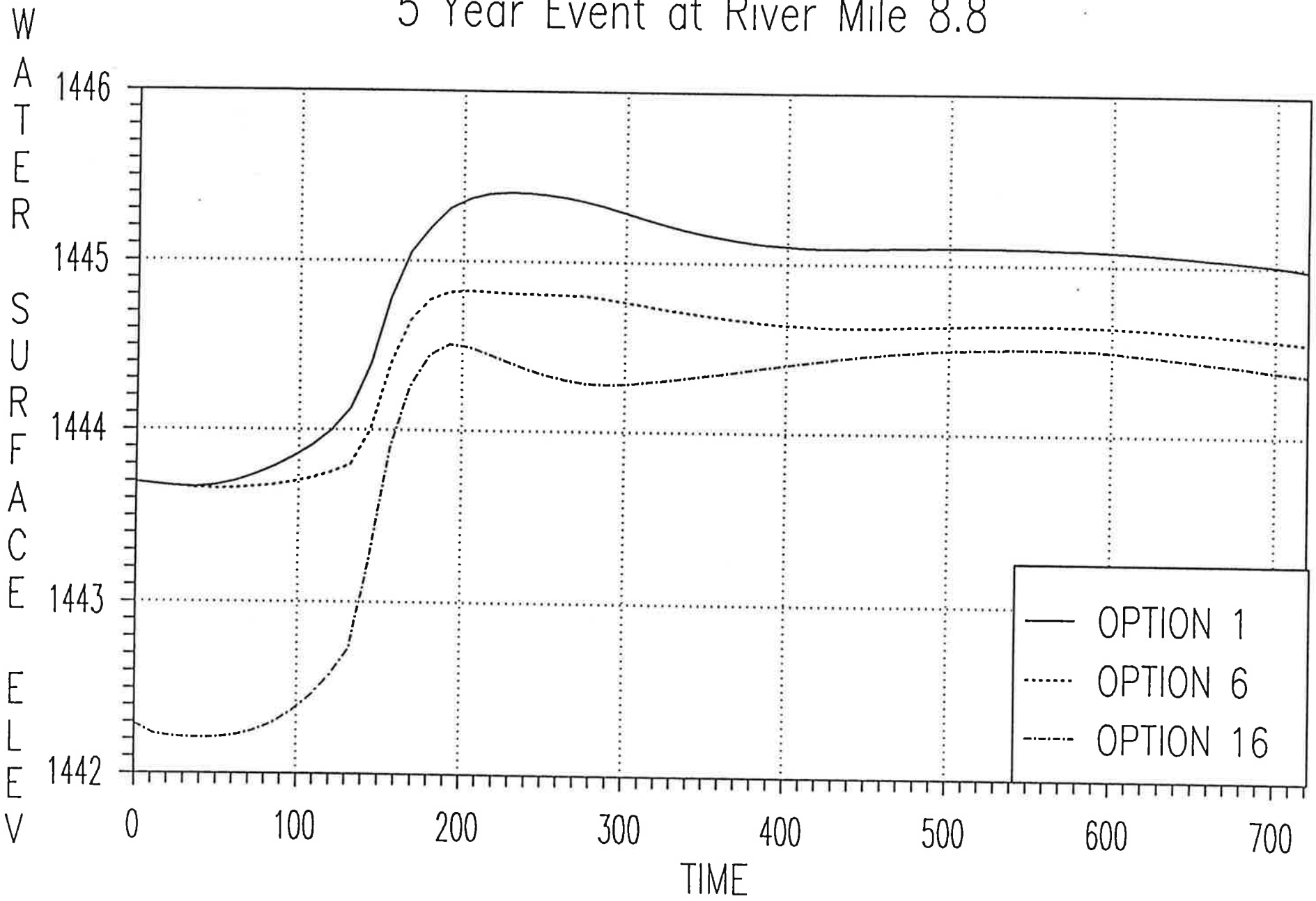
Chain Lake Stage Hydrograph

5 Year Event at River Mile 11.55



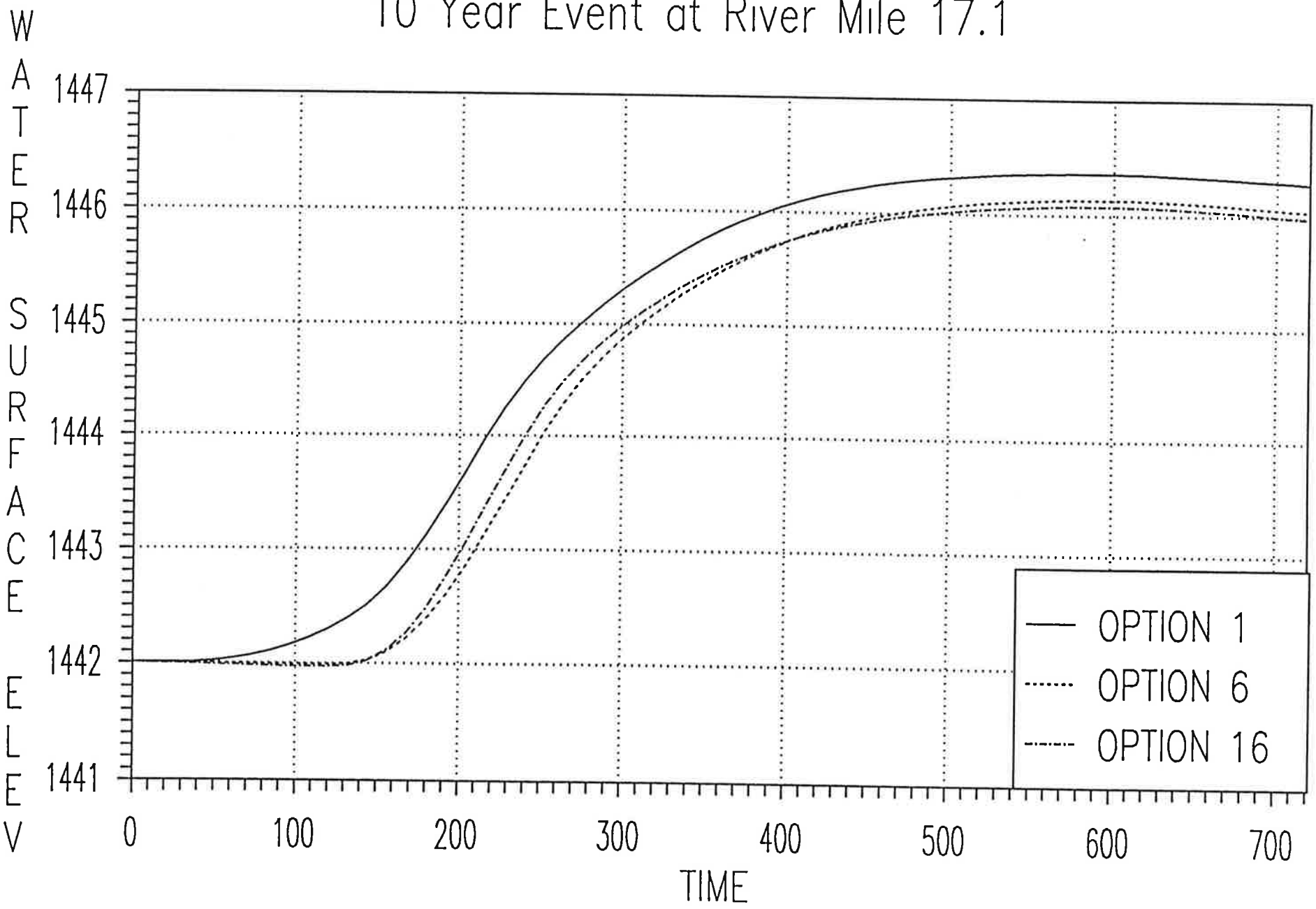
Mikes Lake Stage Hydrgraph

5 Year Event at River Mile 8.8



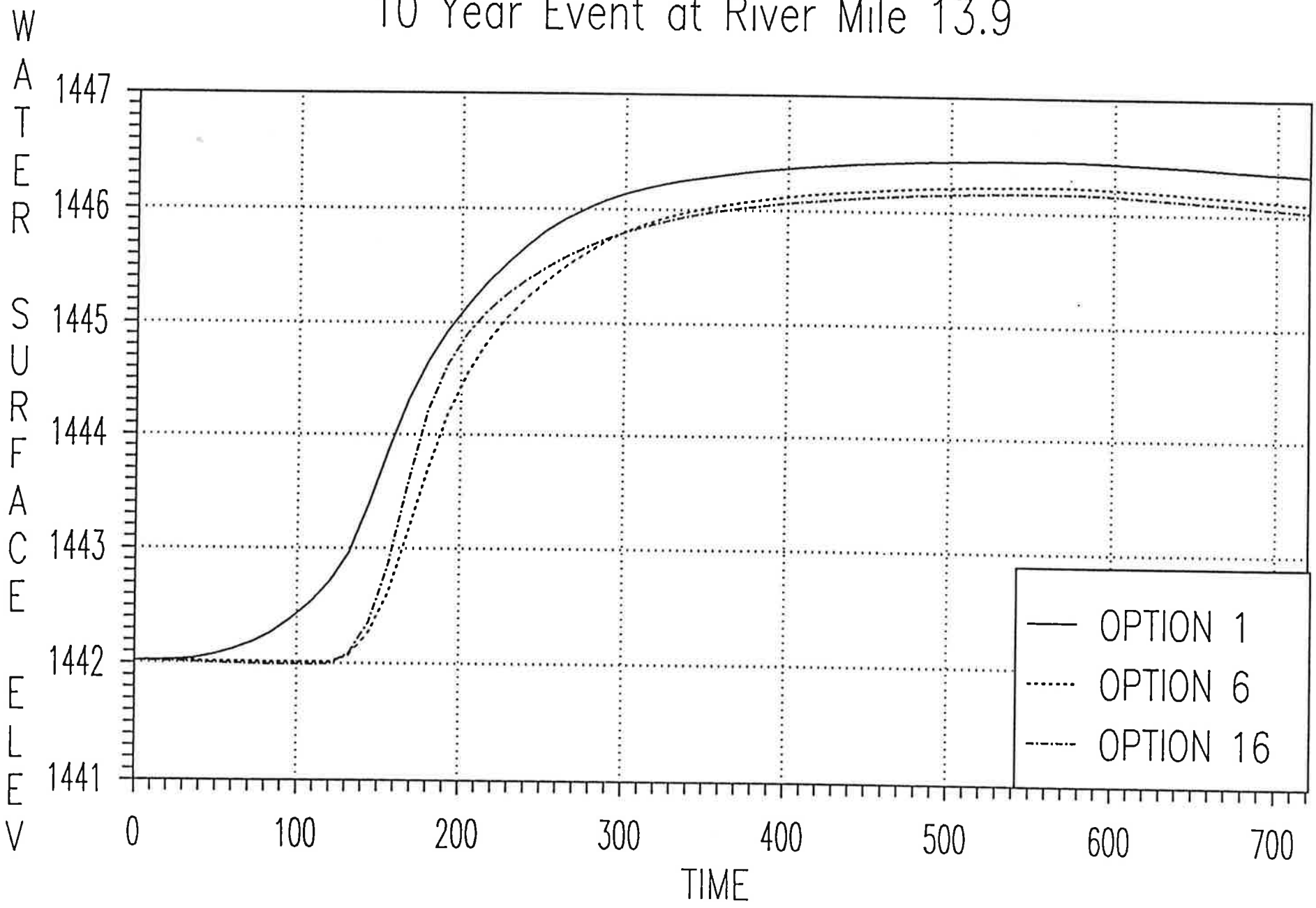
Lake Irvine Stage Hydrograph

10 Year Event at River Mile 17.1



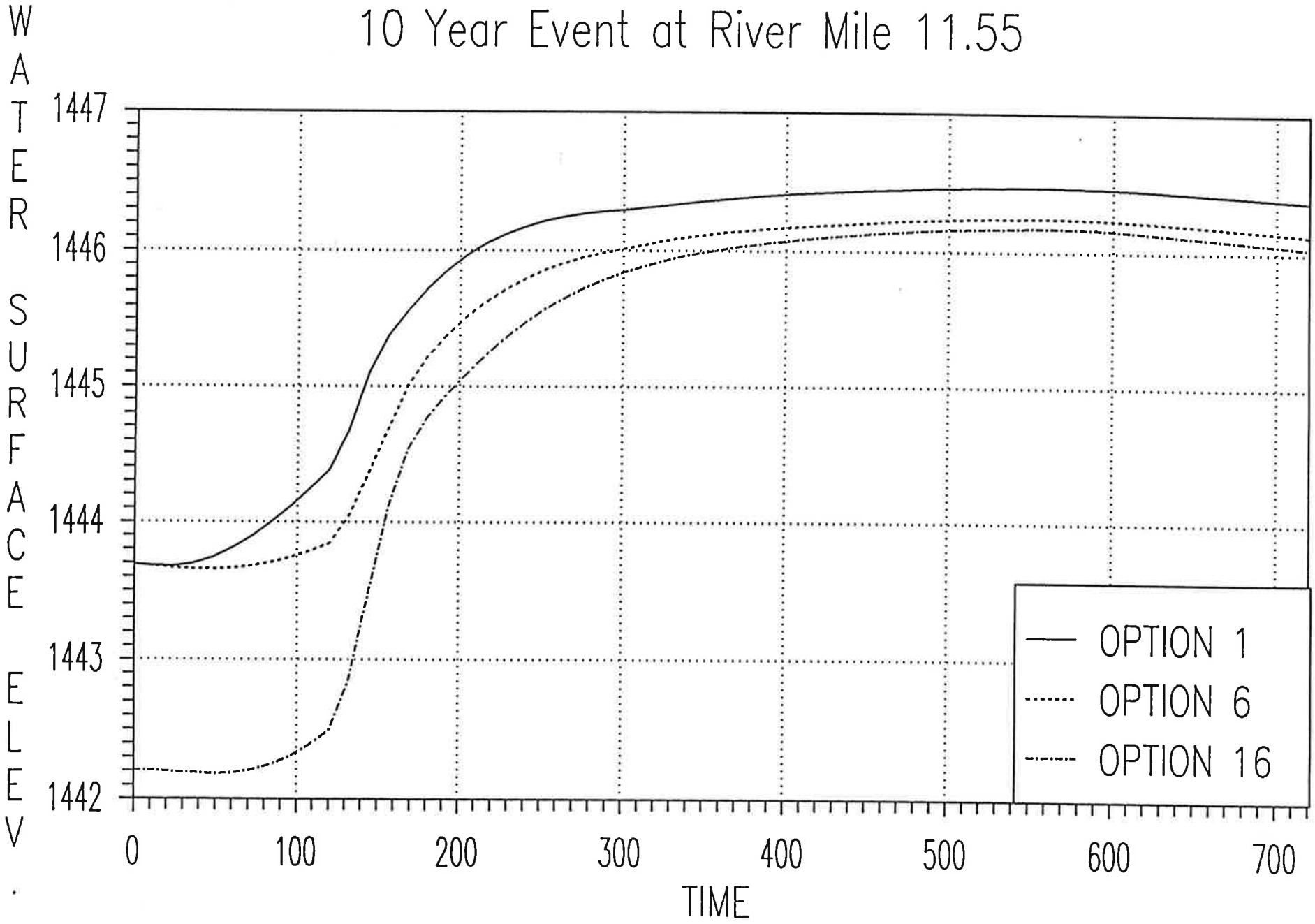
Lake Alice Stage Hydrograph

10 Year Event at River Mile 13.9



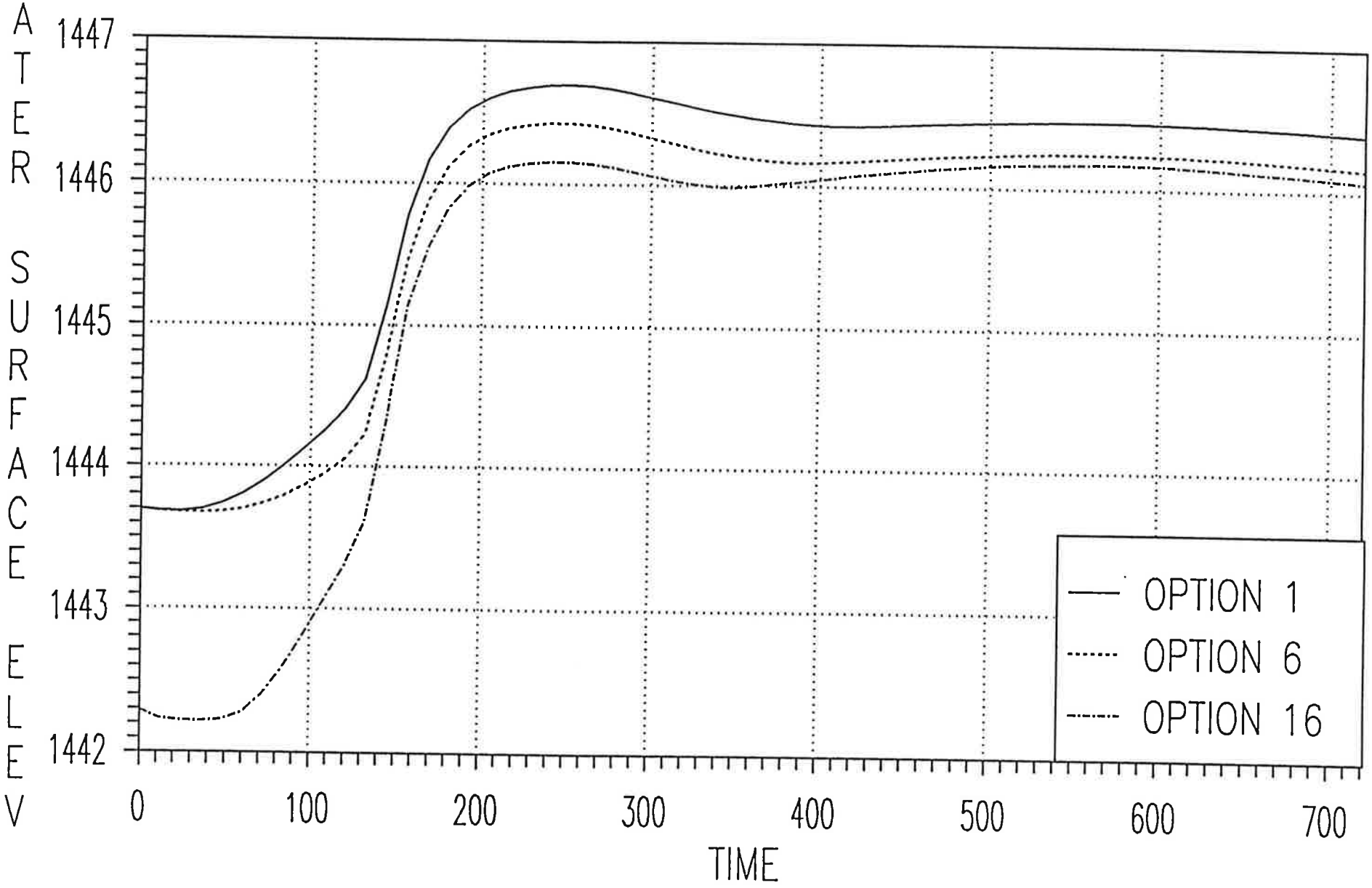
Chain Lake Stage Hydrograph

10 Year Event at River Mile 11.55



Mikes Lake Stage Hydrograph

10 Year Event at River Mile 8.8



Appendix C - Lower Mauvais Coulee Improvements

APPENDIX C
Lower Mauvais Coulee Improvements
Option 2

The location of the structures is shown by the numbers on Figure C-1 and C-2.

Phase One Improvements

Priority	Item	1980 Cost	1991 Cost
1	Replace culverts with bridge at Structure #8	$149,000	$246,000
1A	Install 10' diameter culvert at Structure #8. This has already been completed		
2	Snag and clear 3 miles of coulee between Structure #7 and the confluence with Little Coulee	12,000	19,800
3	Develop a pilot path below Pelican Lake	12,300	20,300

Phase Two Improvements

4	Replace Structure #6	155,000	255,800
	Removal of structure only	10,000	16,500
5	Replace Structure #9	151,000	249,200
	Removal of structure only	10,000	16,500
6	Replace Structure #14	221,000	364,600
	Removal of structure only	10,000	16,500
7	Replace Lake Irvine Control Structure. This was included in the present study as Option #3 and should be done to allow the fall drawdown, Option 6		
8	Raise dikes between Lake Irvine and Highway 2	182,000	300,300
9	Replace Structure #2	182,000	300,300
	Removal of structure only	12,000	19,800
10	Replace Structure #10 (low priority)	182,000	300,300

Priority	Item	1980 Cost	1991 Cost
11	Widen channel between structure #11 and Pelican Lake	50,000	82,500
12	Replace Structure #17 This has already been completed		
13	Raise Highway 19 and the bridge (low priority)	208,000	343,200
13A	Raise Highway 19 and replace the bridge, Structure #15 (low priority)	325,000	536,250
14	Remove Structure #16	6,500	10,700

FIGURE C-1

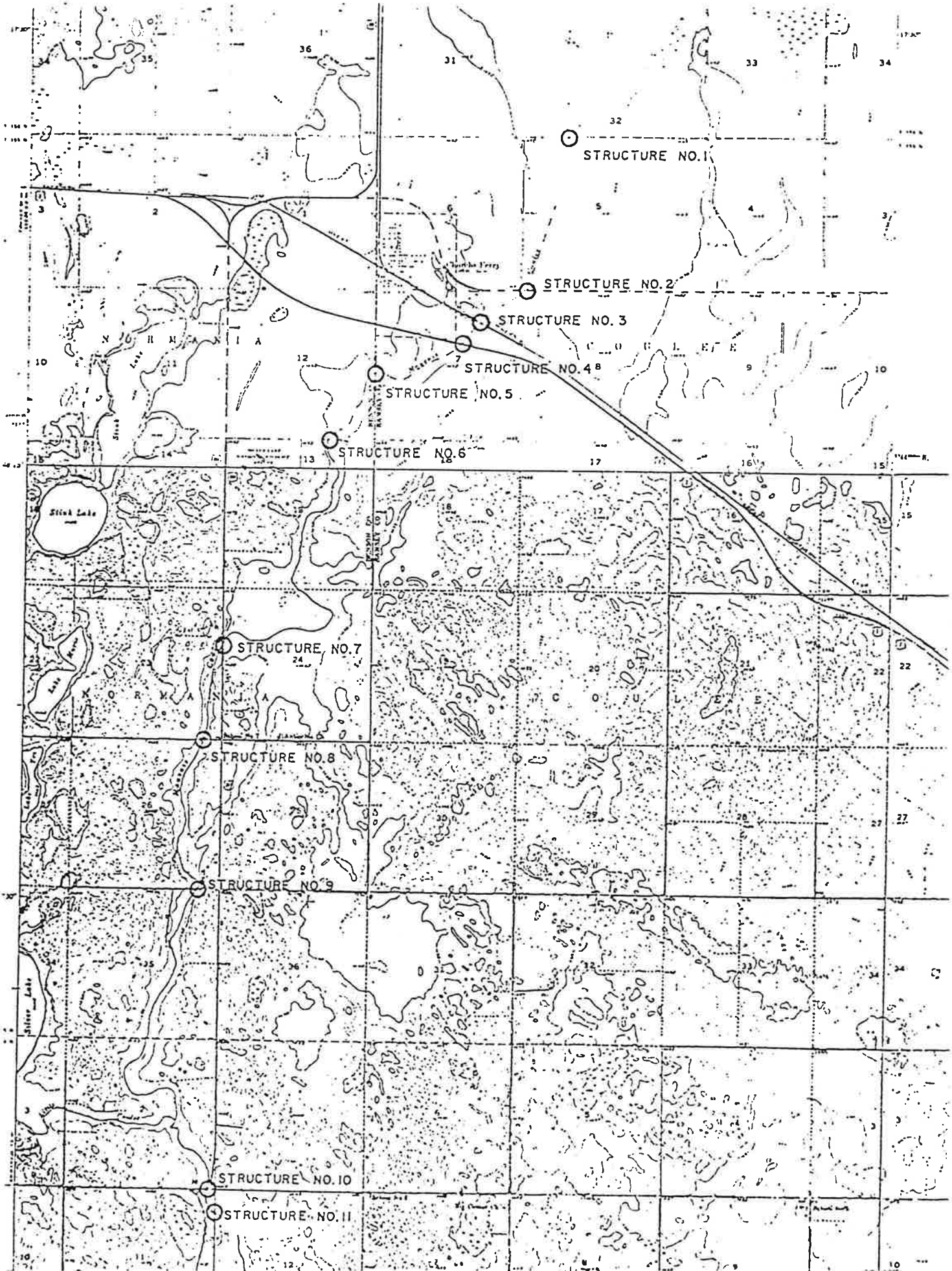
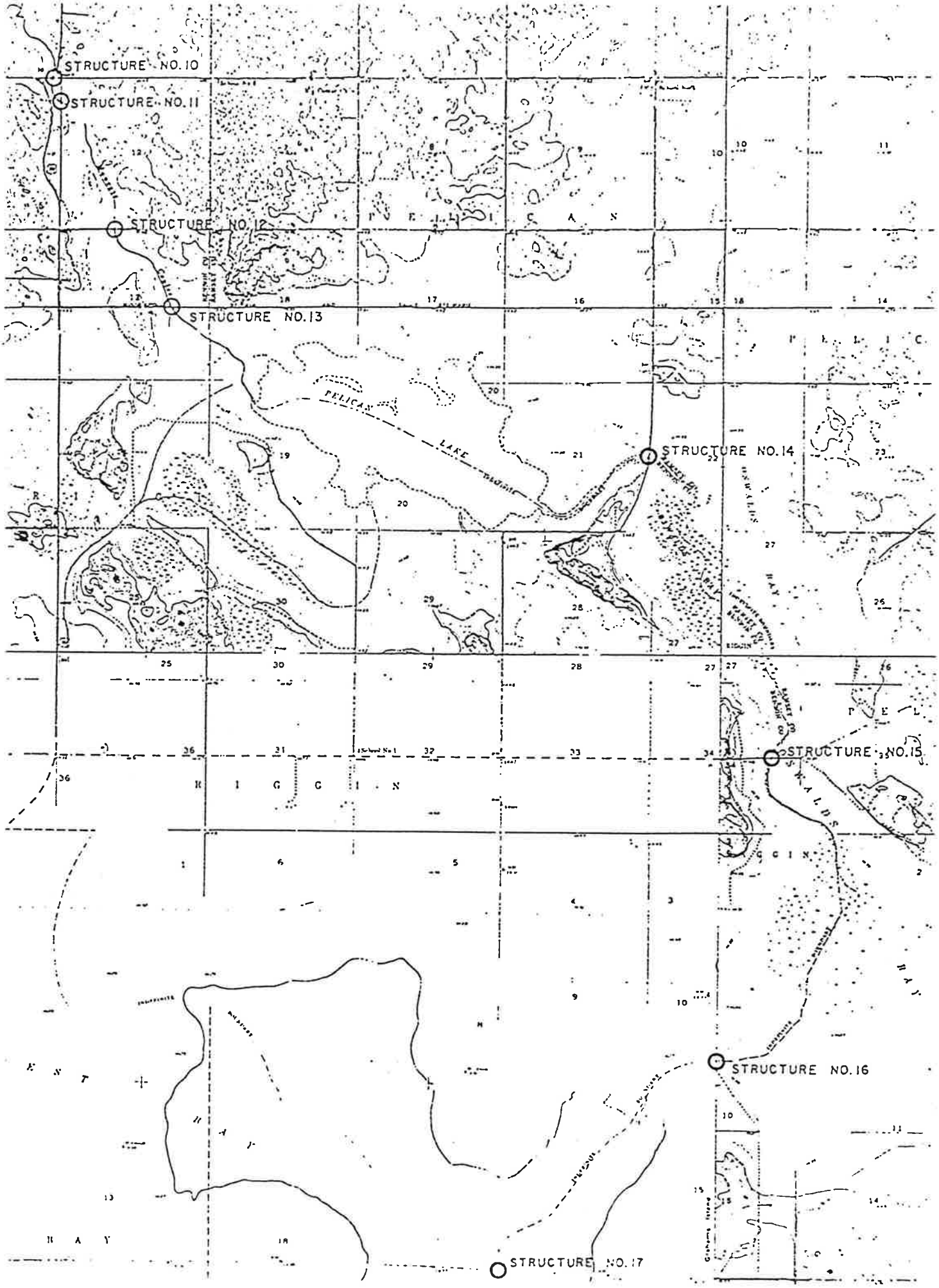

STRUCTURE NO. 1
STRUCTURE NO. 2
STRUCTURE NO. 3
STRUCTURE NO. 4
STRUCTURE NO. 5
STRUCTURE NO. 6
STRUCTURE NO. 7
STRUCTURE NO. 8
STRUCTURE NO. 9
STRUCTURE NO. 10
STRUCTURE NO. 11

FIGURE C-2


STRUCTURE NO. 10
STRUCTURE NO. 11
STRUCTURE NO. 12
STRUCTURE NO. 13
PELICAN
LAKE
STRUCTURE NO. 14
STRUCTURE NO. 15
STRUCTURE NO. 16
STRUCTURE NO. 17